SCHOOL SCIENCE
AND
MATHEMATICS

VOL. LI FEBRUARY, 1951 WHOLE NO. 445

AN INDUSTRIALIST LOOKS AT EDUCATION*

B. D. KUNKLE
General Motors Corporation, Detroit, Michigan

In accepting your very kind invitation to speak to you tonight, I realize that I must be considered somewhat of a hazard, because a person like myself who has spent the major years of his life in industrial operations is liable to think too much in the form of cold steel and straight lines, which does not always coincide too well with the educational process.

You have asked me to give an industrialist's view of education. Therefore the things that I intend to emphasize most particularly will be confined to that viewpoint so that I remain in my own field of operation, for I am fully convinced that in the field of education, all of you know much more than I could ever hope to know.

I learned long ago that one of the most dangerous things I could do was to attempt to step into an operation in the factory about which I knew nothing and try to demonstrate to the operator the best way of doing the job.

I remember an experience I had many years ago when I was a lad. My father was a village blacksmith, and while my experiences did not include agricultural pursuits, nevertheless I did have many friends who lived on farms. One day I visited a friend who was plowing in the field. I followed him as he went along with his job. After we had walked and talked a while, he said, "Would you like to try this?" And I said, "Why, yes, I would." It looked simple enough as I saw him do it, but when I took hold of the plow it was a different matter. Immediately the plow had me running from one side of the

* A talk given at the Fiftieth Anniversary Dinner of the Central Association of Science and Mathematics Teachers, Inc., Edgewater Beach Hotel, Chicago, Illinois, November 24, 1950.

furrow to the other. The boy laughed and gave me a few pointers. After a short while, I began to get an idea of what to do. There were two things I learned: first, I needed to keep a constant watch of the plow in the furrow and of the ground ahead of it. Second, instead of trying to hold the plow rigidly, if I let the plow have some free movement and simply guided it in its course, we both got along better.

In a sense, I am sure that you have had the same experience in the development of your educational programs. After all, you are interested in directing minds in a course. To do this rigidly is a difficult thing, as I have found in handling industrial operations, but it does work out well to allow some flexibility while keeping your organization on the course so that you can accomplish the definite objective in mind. I expect that you find it much the same way in training your pupils in school. While you have to maintain a course in line with your objectives, there must be some freedom and flexibility in order to accomplish the desired result.

I think it highly commendable that educators like yourselves are willing to take a part of your vacation time to meet for the purpose of exchanging ideas and talking over the problems involved in accomplishing your educational objectives.

In the management of an organization, the most satisfactory approach is to select an objective, acquaint your organization with the objective, and then allow the organization members to use their initiative to accomplish the end result.

It would take too much time to follow through our organization process in detail, but there are some things in our automotive industrial operations that I should like to mention because they parallel rather closely the problems that confront you.

Take, for instance, a single unit which we have to deal with in the building of an automobile, such as the automobile body. To the casual observer it is the assembling of smoothly formed metal parts, finished externally and trimmed internally to meet the requirements of the purchaser.

When we stop to analyze the automobile body, however, we see that it is made up of thousands of parts, some of which are fixed rigidly together, others have to have a flexible function in relation to each other. Each one of the parts going into an automobile body has to be studied, designed, inspected and tested. Each one of the parts has to be shaped so that it will fill its place and become a part of the composite body for which it is designed. Although tools are made in order to give these parts their proper shape, we sometimes have difficulty in forming the material in the final shape we want it to be.

No doubt you have had similar experiences in developing the details of your programs. For I assume that each step in your educational process must be designed both from the standpoint of subject matter as well as teaching techniques, so that the knowledge instilled in your students at each step will form a component part of their complete educational process.

We must have a definite objective so that when all the parts of the automobile body are assembled they will make a complete unit. I assume that you too have the same sort of objective, to make the various steps in your educational program form a functioning part of a complete unit—just as when the automobile body is finished, it must be assembled correctly to the chassis in order to become a part of the completed automobile unit.

In an industrial organization, to a degree, men and women have to fit in the same way. Industrial organizations are made of groups of individuals, each one performing his particular function, and, at the same time, bearing proper relationship to the rest of the organization.

As educators you have a wonderful opportunity to guide the young people in your classes in such a way that they not only obtain academic and vocational training but also learn to "get along" satisfactorily with other people. Because, as your graduates go out into the working world, one of the greatest assets that they can have is the ability to function smoothly with their associates, not only at work but in the community as well.

I am not going to take your time to talk about all of the elements that go into making up character and other desirable characteristics necessary in the personal conduct of an individual in a working organization. I am sure you have had these enumerated before and that you have analyzed these characteristics in great detail. But in an industrial organization it is necessary that we have the same characteristics in organizational functions as we do in the characteristics of individuals.

In building a unit such as the automobile, it is necessary that many thousands of parts be brought together in order to make the complete unit. This movement has to be controlled and the flow of parts synchronized so that each part reaches the assembly line at the right time and in the right quantity. This orderly movement of materials, as well as the arrangement of the plant to facilitate their movement, is the result of much study and careful planning by different departments.

It has been interesting to me to read the history of your organization and to learn that mathematics and science were first considered as separate units, but as you went along you found the two were so

closely related that you could function better by having one unit to which you all contributed to accomplish your mutual objectives.

There is so much need for mathematics in science and so much need for science in mathematics that the two working together form a more satisfactory working unit.

Both are developed from experience, and as time goes on, requirements change, making it necessary for both to add to the nucleus already established in order to keep abreast of current conditions.

As we build an automobile, it is necessary not only to design parts, make the tools and fabricate them into a complete unit, but it is also necessary, after these parts are brought together, that we make exhaustive tests to be certain that the parts themselves function properly in their relationship to other units.

Your mathematical and your scientific units have developed in much the same way. I would think that some of you mathematicians would be a bit alarmed over the things we are reading in the papers these days about the machines that are being developed for calculations of difficult problems. One of our men recently witnessed the operation of a machine that had the ability to make 4,000 calculations a minute. He said that if the proper information was put into the machine, the resulting answer could be depended upon for accuracy.

Incidentally, I heard in the course of traveling around that Mrs. Einstein visited this same plant, and after the machine was shown to her she asked its purpose. She was told "to carry out difficult and intricate mathematical calculations." She casually remarked, "Well my husband figures these things out in a few minutes on the back of an old envelope."

While I do not mean to deprecate the importance of mathematical solutions of problems, I was told of an instance that happened not so long ago. A powerhouse was being built on the opposite side of a stream from where the materials arrived by rail. The materials then had to be transferred by barges to the construction site. When the construction was completed to the point of installing some of the heavier equipment, a shipment of very heavy transformers arrived. As the story goes, back at the office they decided there were no transportation facilities adequate for carrying these transformers across. A group of engineers were sent to the scene to give the construction engineer such technical help as he might need. After they arrived, they had a meeting at which the visiting authorities decided that none of the barges were adequate for carrying the transformers. They outlined what they thought would be necessary to take care of the situation. At this point the construction foreman said, "It's too bad I didn't know all this yesterday because I lashed together a couple of the barges and the transformers are over there now."

We find in our organization that practical experience and good judgment combined with educational training make an excellent combination to carry out the responsibilities of management.

Going further with our industrial parallel, in building automobiles we find that we must change the models every year. This is done for two reasons; to introduce improvements in the product and to modify the design to satisfy the public. Unless our automobiles are what the public wants, we go out of business. To accomplish one phase of this, we have a section in our organization known as Customer Research. No doubt many of you have received their questionnaires asking for criticisms and suggestions to help us make our product more desirable. Model changes also provide opportunity to introduce completely new developments such as automatic transmissions and high compression engines which improve the functioning of the automobile from the consumer's point of view.

I appreciate that in your educational program you are frequently up against "model changes" and that your problems may be more difficult than ours because of the fact that you have an established curriculum supported by textbooks that are not too easy to change. But when you do change, your final objective is undoubtedly the same as ours.

In reading your history, I have noted that in the past fifty years you have made many changes both in textbooks and in the teaching techniques, designed to improve both the presentation and the understanding of a specific subject. The one particular point in your discussion which disturbed me was the fact that our older textbooks required too much memorizing on the part of the pupil and that the new approach was to present the problems in such a way that the pupil might come to a natural solution which he discovered more or less for himself rather than to memorize axioms, theorems and definitions.

I quite agree from the days of my old Carhoot and Chute as well as from certain of my textbooks in mathematics that changes of this kind may be desirable. But in our industrial operations to a considerable degree, memorizing subjects at hand is highly important. It has been my experience many times in sitting in meetings with our president, Mr. C. E. Wilson, that when subjects were presented for discussion, he would promptly challenge points not in keeping with policy or past experience. As a result, modifications were made in the presentations based on his exceedingly accurate memory of past experiences and facts. Very often the comment after the meeting would be, "That fellow has a memory like an elephant."

Believe me, in order to coordinate the activities of an organization the size of General Motors, a good memory is a highly important

attribute. I mention this because personally the things that have stayed in my mind best were the things that at the time I did not quite understand, but later was able to comprehend. The very fact of memorizing has been of great use to me in my own personal activities. For this reason, I feel that it is not a punishment to the mind or to the student to induce the kind of mental development that later on will serve a good purpose when the elements of education must be put to practical use.

I have had some experience myself in looking at this matter of education. In our industrial work we accomplish results largely from the use of tools. They may be the small hand tools with which the die maker generates the forms used in shaping our mechanical parts, or again, they may be the larger mechanical tools which are used in removing metal, shaping metal, placing forms for casting or in the casting work itself. While education should provide pupils with the tools of knowledge, it is not expected of the high school graduate or the college graduate going into industrial operation that the skill for using these tools has been completely mastered.

I sometimes think boys and girls with the limited amount of practical work experience they get in school would be better advised to consider this as only a foundation for the later development of skill. Otherwise, having only a limited amount of experience when they enter industrial work, they are disappointed to find they are not regarded as skilled men and women. It is expected that the graduate will have the opportunity to acquire skill in the use of the educational tools just as the apprentice boy acquired skill in the use of tools with which he carries on his trade.

The educational information which you furnish the student is just as definitely a tool as the saw, the square, and the compass which the carpenter uses, but it is by actual use that he acquires skill for producing acceptable work with these tools.

Most industrial organizations actually provide a period of plant training where individuals can accumulate the skills which will allow them to use their educational training in wider fields as requirements and experience dictate. This point is emphasized particularly by the great changes that are going on as the result of scientific research. I remember when I first began to deal with metals that we used largely wrought iron, malleable and cast iron with mixtures not too well controlled. Later, through scientific research we found that by the addition of metals such as tungsten, molybdenum and nickel to form alloys and also by the control of the carbon, silicon and sulphur content we could get the desired strength with greatly reduced weights which has been an important factor in the development of the present day automobile. Wearing

qualities, refined surfaces, lubricants and even the gasoline itself have gone through tremendous changes even in recent years. This emphasizes again the point I made a few minutes ago that you cannot expect to teach even with your very latest textbooks all of the things that your graduates will have to deal with when they take their places in industry or other vocations.

It seems to me most important that students be trained to make an orderly and methodical approach to the solution of any problem rather than being limited to solving problems in the text they may be studying. What I am trying to say is that by emphasizing the method of solution rather than the specific solutions, you will be providing what I call the working tools to apply in situations that may be quite foreign to their past experiences. I realize full well that specific texts, even though they may be relatively up to date, can not be expected to cover exactly the problems your students will meet after graduation.

As an example, I was traveling through California recently and stopped for a visit at one of the airplane plants where they are building jet fighters and jet bombers for military service. I was greatly impressed with what I saw in the construction of these planes, but more so with the fact that in this plant there were 2500 men engaged in engineering and research work. This can readily be understood as necessary because the planes are being built to travel at terrific speeds and operate successfully in altitudes and atmospheres quite different from what we have known in past airplane performances. This means that in the development of the planes, materials, structural features and functioning mechanisms have to be devised, based on new research and experimental data since the material that is now available is largely obsolete so far as these units are concerned. The engineers and research men engaged in this work have little past data applicable to the solutions of current problems, but they follow the fundamental analysis and apply the elements of training which they have had in their previous technical education and experience.

As a youth I had resources of $325.00 when I began my college education. I supplemented my funds by waiting on tables and by other tasks and I was able to carry through, starting with limited means, but I am frank to confess that if I had known all the obstacles I would encounter, I would never have had the courage to tackle them.

My industrial responsibilities in later years have thrown me into situations about which I knew practically nothing but I realized that there was a solution and that by analyzing one part at a time you gradually solved your entire problem.

I remember the time I came into an examination room to take an exam in analytical geometry. The professor had prepared ten questions, each of which presented an original problem to which a standard formula was applicable. But I was convinced upon reading the paper through that I knew nothing about the examination. I read the test through again—then again. After the third reading I saw a problem that I thought I knew how to work. I finished it and started on another. By the time the examination was over, I had solved all ten of the problems—nine of them correctly and the tenth was correct except for a mathematical error.

These are typical of the situations we are constantly faced with in industry. During the last war we were called on to make parts that our organization had never seen before, but by careful analysis we found the proper way to get the required results, so that, like in the analytical geometry examination, we succeeded because we applied what we knew, in the way we knew, to get the desired results.

As I think back concerning the textbooks I studied, the one that stands out most in my mind was a little pamphlet developed by our professor of chemistry, Dr. Pond. He had the reputation of teaching more chemistry in a short time than was done comparatively in any other subject. He insisted on constant attention to the demonstrations and to the text. This pamphlet had one hundred questions, three of them examination questions, but the thing that impressed me was that in between each ten questions were the words, "STOP AND THINK," printed in large type. This left such an indelible impression on my mind that many times when I have found myself confused, when there seemed to be no answer, I have said to myself, "Stop and Think!" And by again applying the process of progressive analysis, a solution was found.

The General Motors Corporation has developed many approaches to the coordination of activities between educational training and industrial requirements. These apply internally as well as to outside contacts. We realize the great responsibility you have toward the boys and girls you turn out. We have a great respect for the training that you give them. Concurrently there is a desire on our part to assist all we can in the development of your educational programs, not with the thought of changing or attempting to direct them, but rather by supplementing where we can be helpful. For this purpose, there is available a good deal of literature and some movies which deal with various activities in our industry and these materials are available to you if in your judgment they can be used to advantage. It is altogether possible that some of you may have made use of this facility; however, for those of you who may not be acquainted with the material offered, there are available samples here in the

hotel which you can look over, and if you feel that some of them will be of help to you, you can signify your needs on the blanks that are available. I am sure that the Educational Service Section of our Public Relations Department will be more than glad to meet what requirements you may have whenever possible. I am not putting in a plug for General Motors particularly but we are interested in helping boys and girls to understand better the problems of industry, especially if that happens to be the particular calling they intend to follow.

Summarizing, from my own personal point of view, there is a great similarity between the problems we have in industry and the problems that you have in the educational field. Just as we try to establish an end result in our products which will function satisfactorily in service, so you are, I am sure, trying to have your educational program shape the boys and girls in mental training so that they too can be of greatest service in their vocations. I would like to emphasize this point particularly because I believe that when graduates take their places in industry, the dominant motive should be to be of service where there is the greatest need. Too often young people shrink away from the more difficult problems. This tendency worries me because in mastering difficult jobs lies the greatest opportunity. The desire to undertake these tasks can best be instilled in boys and girls when they are in your classrooms.

Again, I want to say that I appreciate the opportunity of meeting with you and I commend you most heartily on the purpose of your meeting. I am most impressed with an organization that has carried on successfully for fifty years and whose members will give of their vacation time that they may accomplish better results in their chosen work.

I mentioned earlier that my father was a village blacksmith. His shop was at the crossroads in the country and the only difference between his shop and that of the one in Longfellow's poem was that my father worked under a spreading walnut tree instead of a chestnut.

In the days that I remember in my father's shop, which was a long time ago as you can well appreciate, we did not have many of the things that are available to us today. There were no automobiles; we had no electric lights or many other conveniences that we have today. As a growing boy I could not do the heavier chores in the shop but there were always plenty of jobs that I could do.

As Dad's shop was located near the city, there were many dairymen and farmers who carried produce to market the year around and came to him for their blacksmith work. In the winter when there was a sudden freeze, they would rush their horses to the shop to be roughshod so that they could travel the icy highway. As a

result, many nights my father would work late in the shop and my job would be to hold the light. When the shoes were fitted and ready to nail he would say to me as he drew up the shoeing box, "Now, Bayard, you hold the light so that you can see, then I can see too."

I am sure that one of the primary objectives in your educational work is to have "good light" for yourselves and to hold it so that the boys and girls who are under your training and instruction "can see too."

WHAT IS MEANT BY THE AREA OF A CIRCLE?

BENJAMIN GREENBERG
Eastern District High School
Brooklyn, New York

H. P. Fawcett in developing the nature of proof came face to face with the problem of definition. He felt, and most of us agree, that a good definition of some concept must essentially mean the same to the various people who study the definition.

A satisfactory definition of a circle should have a meaning, clear and precise and should mean the same thing to all people looking at the definition. A survey of numerous textbooks in plane geometry reveals two definitions. The first definition considers a circle as the bounding curve and the area within the curve. (We will refer to this as definition one.) The other definition considers the circle as the curve alone. Nothing is said about the space inside the curve. (We will refer to this as definition two.)

As a matter of interest many plane geometry textbooks were consulted in order to determine whether definition one or definition two was employed. It is interesting to note that prior to 1923 definition one was utilized with an occasional reference to definition two. After 1923 definition two has been utilized almost without exception. This is not too strange when one considers that in 1923 the famous report of the National Committee on Mathematical Requirements was published. They wanted a circle to be defined as the curve, not the curve and the space enclosed by the curve. This report has influenced the writing of textbooks since that time and so it isn't surprising that plane geometry textbooks since that time have utilized the definition of a circle as recommended by the National Committee on Mathematical Requirements.

Another important influence on mathematics, namely the fifteenth yearbook of the National Council of Teachers of Mathematics, also defines a circle as the curve and not the space enclosed by the curve.

It should be mentioned that F. W. A. Young advocated the definition of the circle as the curve in 1907.

Thus far this bit of research has merely uncovered the fact that an important committee often can unify thought on a particular topic or definition. The main reason this article has been written is to point out that most writers of plane geometry textbooks have defined a circle as a curve, but then have gone on to speak of the area of a circle. Strictly speaking there is no such thing as the area of a circle since a circle is defined as a curve and not as the figure enclosed by the curve. When the authors of the textbooks who define the circle as the curve come to the topic of "areas" of circles they should point out in their textbooks that there is no such thing as the area of a circle, but what is wanted is the area of the figure enclosed by the circle. After this has been specifically mentioned in the textbook, then the author should point out that thereafter when he speaks of the "area" of a circle he actually means the area enclosed by the circle.

SOME PRACTICAL SUGGESTIONS FOR THE TEACHING OF BIOLOGY*

FRANCIS D. CURTIS
University of Michigan, Ann Arbor, Mich.

The one who attempts to discuss a topic such as this is bewildered by the innumerable aspects that could appropriately be considered. A selection is mandatory. Only a few important issues, presented as theses, will, therefore be briefly reviewed. Although these theses will be stated dogmatically, as if they were unquestionably true and unchallengeable, the procedure is not intended to conceal the fact that they are chiefly opinions, only a few of which are strongly supported by the findings of educational research.

1. *Biology is potentially one of the most valuable subjects in the entire program of studies of the secondary school, and hence, should be a required part of every pupil's education.*

The applications of biological knowledge in daily living are too numerous and too obvious to require emphasis. But it is not so readily apparent, or so commonly realized, that a knowledge of biology provides the necessary foundation for optimally fruitful study of many subjects outside the conventional fields of science. Prominent among these subjects are history, English, sociology, economics and psychology. To illustrate, how is a complete understanding of such common phenomena of history and sociology as migration and conquest possible without a comprehension of the biological factors that control the survival of organisms and of the basic biological meaning of "struggle for existence"? Again, the pupil who applied his understanding of biology in his English class, by stating that the *real* reason why Gawain left his mother's castle to visit the court of King Arthur was the migratory impulse of mature young males of gregarious mammals, came much closer to the true explanation than his astounded teacher and derisive classmates were qualified to know.

2. *The justification for a course in general biology, as for any other course, lies in the definiteness and practicability of its objectives. These objectives should specify types of training for efficient present and future living, that the course can and will be made to provide.*

Many announced objectives of courses are really statements of philosophy, often not much above the level of wishful thinking. Other objectives of courses confuse goals with the means of attaining them. Examples of such objectives might be, "To acquaint the pupils

* Presented before the Biology Section of the C.A.S.M.T. at its "Golden Anniversary" Convention, in Chicago, November 24, 1950.

with the most important contributions of biologists, past and present," and "To acquaint boys and girls with the world of living things." Clearly such goals are not ends in themselves. There must be a bigger purpose beyond each of them, than merely that of exposing the pupils to these aspects of biology, desirable as they unquestionably are. Such purposes might be indicated by extending the stated objectives somewhat like this: "To acquaint the pupils with the most important contributions of biologists for the purpose of giving them precise training in the use of scientific method for discovering truth," or "To acquaint the boys and girls with the world of nature as one means of developing their resources for leisure enjoyment."

In constructing a biology course, therefore, the first question to be decided is, exactly what kinds of *training* should this course provide? The answer to this question will vary with different individuals, for there is no general agreement with respect to what the goals of the course should be. Obviously, however, it must include training of sorts that seem likely to ensure more efficient present and future living for the pupils.

The next step is the selection of the appropriate materials, to provide both the setting within which, and the means by which, the desired training, as specified in the objectives, can be given. The course content, then, falls into its proper place in course planning. It is not something to be learned as an end in itself. Instead, it is something to be used as a means of gaining desired ends. Moreover, texts, supplementary references, visual aids, laboratory exercises, observation of plants and animals and all the rest of our teaching resources become merely the tools and implements for the types of training specified in the statements of objectives.

3. *A textbook provides the best basic source of materials for a course in general biology.*

We have long been hearing the ill-considered statement that "We must get rid of the textbook." When interpreted literally, this statement connotes that there are no values whatever to be derived from the use of textbooks for any purposes. But the Forty-sixth Yearbook of the National Society for the Study of Education[1] defends the textbook. It states that, whatever the faults of the modern textbook in any course may be, the book seems likely nevertheless to provide a better array of materials than the average teacher can possibly improvise from the available resources and within the time at her disposal.

It is difficult to imagine the complete futility of certain biology

[1] Forty-sixth Yearbook, National Society for the Study of Education. The University of Chicago Press, 1947. P. 48.

courses that were offered a few years ago in schools that accepted literally the dictum "We must get rid of the textbook." These courses were characterized by nebulous, garbled and highly inaccurate reports on miscellaneous topics related to biology, that teachers and pupils had found more or less sketchily reported in newspapers and magazines, or had heard discussed on the radio.

Admittedly textbooks have their faults. Moreover, there is no textbook of biology, or for that matter of any other subject, that is unquestionably the best. But among the thirty or more biology textbooks currently available, there must be one that appeals to each teacher of the subject as being the best one for her particular teaching situation. A sane procedure, therefore, is to make this book the basic source of materials for the course, and to select from it the series of units and their subdivisions that seem likely to prove most appropriate and potentially valuable. This selection of material will then provide both a more or less complete outline and the common core of the course, which every member of the class will study. Then this basic core should be abundantly supplemented with materials from other texts, reference books, and all other available sources.

The misleading slogan "We must get rid of the textbook," needs to be restated so that it will more accurately and intelligently express its probable intent. It should be amended thus, "The materials for no course should be confined to the contents of one text."

4. *The primary function of tests in a biology course is to provide a means of diagnosing faulty learning, as a basis for reteaching.*

The pupils and their parents like to make teachers and others believe, if they can, that a failure in a test or a course is always the teacher's fault. Such a reaction is absurd, of course, and should not be countenanced. Faulty learning may be due to poor teaching, but it is more likely to be attributable to other factors, prominent among which is the lack of the pupil's ability or effort. But no matter whose fault inadequate learning may be, it is the duty of the teacher to identify the elements that have not been learned satisfactorily and to reteach them.

Short-answer tests provide probably the best means of such diagnosis and a substantial help in reteaching. In fact it may be said that the *chief* purpose of short-answer tests is to discover faulty learning as a basis for reteaching. Furthermore, there is abundant and unchallenged evidence, that with short-answer tests the most effective reteaching can be achieved by a procedure that requires the expenditure of practically none of the teacher's time or energy out of class. The technique consists of having the pupils make their responses to the test items with colored pencils all of the same color.

Upon the completion of the test the pupils exchange papers and exchange also their colored pencils for those of another color. The items are then discussed, one by one. This discussion is the significant factor in effecting relearning; the evidence shows that little relearning is accomplished by the test without it. Each pupil then merely marks a check (√) opposite the number of every item to which an incorrect response has been made as that item is discussed. When all the items have been discussed, every pupil signs the paper that he has checked and returns it to its owner, who is then free to ask such questions about the items as he may wish to ask.

To discourage dishonest checking, the teacher tells the class before the discussion of the questions begins, that she will examine a sample (a few) of the papers and will charge against the test score of a pupil any errors that he made in checking incorrect items. The effectiveness of this safeguard is evidenced by the fact that in two high schools, over a long period of time, the number of test items incorrectly checked by pupils ranged from one in every seventeen to one in every four hundred. It is questionable whether teachers, if confronted with the task of checking the incorrect responses on all the papers, especially at the end of a trying day, would make fewer errors.

5. *Every test in general biology should include a large proportion of items that measure the ability to apply factual information.*

Analyses of teacher-made short-answer tests, not only for general biology, but for every other branch of high-school science as well, have revealed that practically all the items have tested merely the recall of facts. The reason for this is doubtless that short-answer test items that measure the recall of facts are the ones easiest to make.

Certain research evidence has revealed that an occasional dull-normal pupil is able to perform as well as some of his brightest classmates, on a short-answer test that measures only the recall of facts. This evidence suggests that the ability to remember discrete bits of information is less closely correlated with high intelligence than is the ability to reason from such information. Such evidence constitutes an indictment of purely factual tests, in addition to the more serious one that stressing the knowledge of facts as an end in itself tends to minify and obscure the efforts to achieve valid major aims of the course.

Recently substantial progress has been made toward testing with short-answer items, reflective thinking, or the ability to reason from factual information. Samples of types of these text items follow:

TYPES OF SHORT-ANSWER TEST QUESTIONS THAT STIMULATE REFLECTIVE THINKING

I. *Modified True-False.* Indicate each correct item by writing *R* in the blank. Make each incorrect item correct by substituting one or more words for one or more of the italicized words. Draw an *X* through each italicized word for which you make a substitution.

Item 16. The wolverine, which a century ago was plentiful in Michigan, is now probably extinct there. This statement is an example of the principle, "Life is distributed in ~~*space.*~~" — time — 16

Item 17. Using hands for grasping and your feet for walking is an example of ~~*protective adaptation.*~~ — division of labor — 17

Item 18. A bird's wings and an elephant's front legs are *homologous structures.* — R — 18

II. *Completion.* Write in the blank at the end of the line the word, or words, necessary to make the statement true.

Item 19. Squirrel, snake, monkey, mouse, dog, cat. All these animals are —?— and all but the snake are —?—. — vertebrates or chordates (either) — mammals — 19

III. *Modified Multiple Response.* If the correct ending of the statement is among those numbered, put the number of that ending on the blank. If the correct ending is not among those numbered, write the correct ending in the blank.

Item 20. An example of a protective adaptation in a house cat is (1) yellow fur; (2) thick fur; (3) yellow eyes; (4) ability to mew; (5) bones in its tail. — 2 — 20

Item 21. When hunting deer, a man is acting like (1) a scavenger; (2) a parasite; (3) a commensal; (4) an invertebrate; (5) a saprophyte. — predator or independent organism (either) — 21

Item 22. Which one of the endings makes the following statement *false:* Clearing land for farms and cities reduces the number of wild animals by (1) reducing their cover; (2) reducing their food supplies; (3) reducing their roaming ranges; (4) destroying both wild-plant and wild-animal life; (5) destroying most of the enemies of the wild things; (6) changing the habitat. — 5 — 22

IV. *Matching.* Write in the blank at the end of each numbered phrase in B, the number of the only numbered item under A that explains, illustrates, or is otherwise associated with that numbered phrase.

A	B		
(1) Reforestation	Lack of enough calcium in soil	8	23
(2) Inorganic matter	Restores fertility to the soil	6	24
(3) Violent wind storm over loose soil	The leaves of growing plants	10	25
(4) Evaporation from the soil	Directly causes sheet erosion	3	26
(5) Over-stocking grazing land	Helps greatly to maintain the water table	1	27
(6) Nitrogen cycle	Bacteria living in clover roots	6	28
(7) Enemies of forest plants	Arid land	11	29
(8) Malnutrition			
(9) Changing rocks to soil			
(10) Photosynthesis			
(11) Scanty rainfall			

6. *Individual laboratory work is an essential part of every course of general biology.*

Throughout the country most courses of general biology include laboratory work. In some schools, especially those in which general biology is taught in the ninth-grade by the junior-high-school teacher, where such conditions exist as over-large classes, teachers inadequately prepared in the various aspects of general biology, and a paucity of laboratory equipment, there is evident a tendency to eliminate laboratory work altogether or to confine it to a relatively few demonstrations.

The Forty-sixth Yearbook of the National Society for the Study of Education[2] and probably all other authoritative pronouncements emphasize the necessity not only for laboratory work in all courses of science, but also, for some experiments to be performed by every pupil, individually, in every science course.

7. *The effectiveness of general biology is seriously reduced if the laboratory work must be carried on at any regularly scheduled time or in any regularly scheduled room.*

The most effective time for undertaking any aspect of a course is that time when that particular procedure, device or activity can integrate most closely with what precedes and what follows, and can therefore contribute optimally to the learning. This statement would seem platitudinous; yet it does not reflect common practice with respect to the laboratory work. The prevailing practice for biology (as for physics and chemistry) has always been to schedule the laboratory work for certain days of the week, and where the facilities have permitted, the pupils have performed their experiments in a laboratory separate from the classroom. Such a schedule renders impossible an optimal integration of the laboratory work with the activities of the classroom. In other words, such a plan inevitably results in not one course of biology, but actually two, a discussion course and a laboratory course. Usually, moreover, the laboratory work lags behind the class discussions. One unit is being studied in the "recitation' periods, while an earlier unit is being considered in the laboratory periods. As a result, the laboratory work serves chiefly the relatively unimportant function of merely providing the pupils with the chance to verify what they have previously learned in class to be true. The practice completely eliminates the possibility of using the invaluable inductive method, in which the laboratory work frequently precedes most of the classroom discussions and the study of the text content.

Ideally, all the work of the course that is carried on inside the school, should be done in one room, that is a combination classroom

[2] *Op. cit.*, p. 53.

and laboratory. Then experimenting can be introduced when it will be most effective. It can be undertaken at any time during a period or it can be carried on during several consecutive periods, as the need for it arises.

8. *In the typical class in general biology, much time is wasted and inferior results are achieved by having the pupils make representative drawings of structures.*

At its beginning, general biology consisted of separate simplified versions of three introductory college courses in botany, zoology and "human biology" (physiology). As would be expected, the methods and procedures employed in the beginning college courses of that time were largely incorporated into the new high-school course. In college courses in the three subjects, then as almost universally now, a standard procedure was that of requiring the pupils to make representative (detailed and accurate) drawings of the specimens that they observed through their microscopes. Such a practice in introductory courses at the college level is usually defended on the grounds that these courses are primarily designed as the foundation ones in the training of specialists in the respective biological fields. In the high school, however, requiring the pupils to make representative drawings cannot thus be justified. In fact, this practice diminishes the values of the course.

This last statement is not a matter of opinion. The findings of perhaps twenty research investigations, beginning with the classic one by Ayer[3] in 1915, indicate that the stronger the emphasis that is placed upon artistic laboratory drawings, the less is the amount of science learned. The conclusion to which these findings logically lead is that representative drawings should be eliminated from the high-school biology course, and that simple diagrams and sketches should be substituted for them. Pupils can learn to make these simpler drawings neatly and quickly.

The negative correlation consistently indicated in the group of researches just mentioned, between effort spent on making representative laboratory drawings and results in terms of learning, should be sufficient to discourage all efforts to construct a "core curriculum" by combining the biology and art courses.

In occasional classes, especially dull-normal groups, is observed the practice of having pupils trace representative drawings from their textbooks or from college textbooks. Some teachers justify this practice on the grounds that it keeps the pupils enjoyably busy. Psychologists would unquestionably agree that this procedure has

---

[3] Fred Carleton Ayer, *The Psychology of Drawing with Special Reference to Laboratory Teaching*. Baltimore, Maryland: Warwick and York, Inc., 1916. Pp. 107–168.

little, or nothing, to commend it. They would probably concur in the judgment that such knowledge of the structures and their relationships to one another, as the pupils might derive from tracing representative drawings of them, could be taught more effectively by other means. Moreover, it seems reasonable to assume that the chief appeal of tracing drawings, to such pupils as assert their liking for it, is due to its providing largely effortless entertainment and to its postponing the time when they may be required to engage in more demanding tesks.

An excellent practice, when indentification of structure with function is the objective, is that of having the teacher supply the pupils with copies of sketches that she has duplicated for the purpose. On these sketches, the pupils mark the appropriate designations or add them.

9. *The use of the microprojector eliminates in the general biology course the need for more than one, or a few, compound microscopes.*

It was formerly considered a desirable goal, wherever the financial resources of a school made it practicable, to supply eventually one compound microscope for every two or three pupils in a biology class. It was discovered, however, that even when the desired number of microscopes had been obtained, the results were less satisfactory than had been anticipated. It was soon demonstrated that more than one pupil cannot study the same specimen optimally by viewing it in turn through the same microscope. Moreover, when serviceable microprojectors became available, it was found advantageous to substitute their use for most of the work previously done with microscopes.

The *microprojector* is not, however, a complete and perfect substitute for the compound microscope in the general biology course. Some of the satisfaction that pupils get from taking the course is derived from learning how to use the microscope properly and from using it in gaining some first-hand acquaintance with the world of minute living things. Learning how to use a microscope properly can effectively be made an individual project, directed not by the teacher, but by one or a few of the most competent class members, to whom the teacher has given the careful instruction needed to fit them to discharge this important responsibility. These selected helpers can also be taught to assist their classmates in distinguishing between bubbles and micro-organisms in freshly-made slides.

10. *Motion pictures in the classroom are often more a handicap than a help.*

This thesis must not be interpreted as denying or minimizing the substantial and important values to be derived from the optimal use of films. But even in school systems that own their own teaching

films, it is rarely possible for a teacher to obtain the one she desires at exactly the time when it could make its greatest contribution. Commonly films must be scheduled long in advance. Inevitably they often become available at times when they cannot be closely related to the aspects of the course then under discussion. This situation is likely to be more aggravated for biology than for other subjects, because of the greater demand from the elementary grades for motion pictures portraying aspects of nature. In every case, in which for any reason a film is only available too early or too late, the disadvantages of showing it are likely greatly to outweigh the possible benefits from its exhibition.

11. *Field trips and excursions can be highly valuable, but they can also prove unjustly expensive of time and energy.*

A field trip or an excursion that is skillfully planned and carried out can constitute a great and unique contribution to the course. But like every other teaching resource, field trips and excursions have potentialities that may, or may not, be realized. Moreover, we cannot dependably assay their values on the basis of the enthusiasm that the pupils customarily display for them. This enthusiasm may in some cases be due either to the welcome shift from the routine of classroom and laboratory (often justified) or to the hope of an easier day than usual.

Field trips and excursions are admittedly difficult to administer. After it has been ascertained, moreover, that such efforts to utilize community resources are administratively possible and that they will not evoke undue opposition from teachers of other subjects, whose classtime may be sacrificed to the activity, then it is still necessary, before a field trip or an excursion is scheduled, to arrive at affirmative answers to two questions: Can a satisfactory visit be carried out in the available time? Are its potential contributions to the objectives of the course likely to be sufficient to justify the time and effort that must be expended?

In some cases, though by no means in all, a careful consideration of these questions will lead the teacher to conclude that the time and energy entailed can be better invested in other ways.

Summary

This paper has been devoted to brief discussions of the following theses:

1. Biology is potentially one of the most valuable subjects in the entire program of studies of the secondary school, and hence should be a required part of every pupil's education.

2. The justification for a course in general biology, as for any other course, lies in the definiteness and practicability of its objectives.

3. A textbook provides the best basic source of materials for a course in general biology.

4. The primary function of tests in a biology course is to provide a means of diagnosing faulty learning, as a basis for reteaching.

5. Every test in general biology should include a large proportion of items that measure the ability to apply factual information.

6. Individual laboratory work is an essential part of every course of general biology.

7. The effectiveness of general biology is seriously reduced if the laboratory work must be carried on at any regularly scheduled time or in any regularly scheduled room.

8. In the typical class in general biology, much time is wasted by having the pupils make representative drawings of structures.

9. The use of a microprojector eliminates in the general biology course the need for more than one, or a few, compound microscopes.

10. Motion pictures in the classroom are often more a handicap than a help.

11. Field trips and excursions can be highly valuable, but they can also prove unjustifiably expensive of time and energy.

To these, perhaps one more thesis should be added without discussion:

12. There is no method of teaching that is so likely to be poor as the best one we know, if we use it all the time.

"MAGDEBURG HEMISPHERES" OUT OF SUCTION CUPS

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

Some years ago I reported a demonstration of atmospheric pressure[1] wherein I used a rubber suction cup and a smooth-faced metal plate. To each is attached a hook so that when the cup is "fixed" to the plate the force required to separate them (normal to the faces) can be measured conveniently by loading. This demonstration, I now quite accidentally observe, can be extended to emulate the classical Magdeburg hemispheres. And they are substantially cheaper!

If two suction cups are carefully placed face to face and "squeezed" together the resulting device provides a cheap substitute for the standard metal hemispheres which are evacuated by pump. Since these cups are available in several sizes the usual class contest which prevails among the "strong men" can be extended to include the woman contenders!

---

[1] Julius Sumner Miller, *American Journal of Physics*, June 1942.

AN EXPERIMENT IN THE DIAGNOSIS AND REMEDY OF ERRORS OF COLLEGE FRESHMEN IN ARITHMETIC AND RADICALS

E. A. HABEL
Pensacola Junior College, Pensacola, Florida

The assumption that college freshmen actually have the necessary skills in mathematics because they have passed the required courses at some time during high school is so glaringly false that any system of education depending strongly upon its truth cannot be highly effective. The failure of this assumption in practice may be a chief factor contributing to student failure.[1] Just as invalid appears the assumption either that deficient students will of their own volition effectively study outside to strengthen their weaknesses or that deficiencies will eliminate themselves through the normal course of instruction as the class progresses. The purposes of this article are (1) to present a partial description of teaching based upon assumptions diametrically opposed to those above, (2) to determine the extent to which a conventional course in general mathematics or college algebra prepares for success in dealing with percentage and the arithmetic of trigonometry and (3) to gain some insight into the relative difficulty of certain fractional and radical problems in arithmetic.

Acceptance of the philosophy that you must "take the student where you find him and carry him along as far as you can" in mathematics poses the following dual problem: (1) What is the present status of the student? (2) For those students whose status is low, what remedial measures should be used to enable them to maintain the pace of the rest of the class? The tests constructed for the purpose of determining the present status of the student were patterned after ones made by Keller, Shreve and Remmers at Purdue University and Wolfe at Brooklyn College and contained, in addition to certain items on percentage, arithmetic judged to be prerequisite to trigonometry. Approximately equivalent forms of these tests were given at the beginning and end of a semester in freshman mathematics to measure relative improvement on various types of items.

Results of these tests are found in Table 1, which affords a means of comparing errors made on the *First Test* administered at the beginning of the semester with errors made on the *Second Test* at the conclusion of a semester's work in mathematics. The actual items of the *Second Test* are arranged in Table 1 in the order of decreasing difficulty for the total group of sixty-one who took the *Second Test.*

[1] Wolfe, Jack: *Experimental Study in Remedial Teaching in College Freshman Mathematics.* Abstract of a Dissertation. Journal of Experimental Education, 10: 33–37, September, 1941.

TABLE 1. Errors Made by 124 Students on FIRST TEST and 61 on SECOND TEST

Rank in Difficulty (2nd Test)	Type of Item (from 2nd Test)	Errors on FIRST TEST				Errors on SECOND TEST		
		Alg. Class 29 Fresh.	Gen. Math. 89 Fresh.	Anal. Geom. 6 Sophs.	Per Cent of 124 Missing Item	Per Cent of 61 Missing Item	Alg. Class 23 Fresh.	Error Made Most Frequently on Each Item
1.	$(\sqrt{13}-\sqrt{2})^2$	16	72	0	70%	64%	10	13−2, or 11
2.	$\sqrt{1-\left(\frac{\sqrt{7}}{5}\right)^2}$	7	68	0	60	62	9	$\sqrt{\frac{18}{25}}$
3.	$\frac{\sqrt{1-\frac{1}{3}}}{3}$	12	69	5	69	51	2	$\frac{\sqrt{\frac{2}{3}}}{3}$
4.	$\frac{8+4\sqrt{7}}{4}$	3	58	0	49	43	1	$\frac{8+\cancel{4}\sqrt{7}}{\cancel{4}}$
5.	$\sqrt{25+36}$	9	54	0	50	41	3	11
6.	$\frac{7}{\sqrt{3}}$	8	44	2	43	40	1	$\frac{49}{5}$
7.	4.967 ÷ 7.6 to 3 decimals	7	68	0	60	34	6	Error in rounding
8.	$\frac{2}{9}\cdot\frac{9}{7}-\frac{5}{9}\cdot\frac{3}{7}$	2	37	2	33	31	10	$\frac{14}{63}\cdot\frac{81}{63}-\frac{35}{63}\cdot\frac{27}{63}$
9.	$\frac{\frac{1}{3}+\frac{1}{3}}{\frac{1}{3}-1}$	13	39	3	44	26	2	Computational error
10.	Write 4.9% as a common fraction	13	55	2	56	25	4	$4\frac{9}{10}$
11.	$\frac{84}{28}\div\frac{36}{49}$	6	23	1	24	23	2	Reducing error
12.	4.78 ÷ 0	25	58	0	67	23	5	Zero
13.	Write .005 as a per cent.	5	35	1	33	21	4	5%
14.	.97 ÷ .0065 to one decimal	9	27	1	30	21	5	Computational error
15.	0 ÷ 68.2	4	33	1	30	20	7	Impossible
16.	$\frac{7}{51}+\frac{5}{17}$	4	25	2	25	20	1	$\frac{374}{867}$
17.	$\frac{18}{7}\div\frac{8}{9}$	1	29	0	24	18	3	Computational errors
18.	$\sqrt{\frac{7}{100}}$	9	60	1	56	18	0	$10\sqrt{7}$
19.	What per cent of 50 is 11?	12	38	3	42	18	5	$\frac{50}{11}=4.6$
20.	$\frac{3-4}{3-7}$	5	30	0	28	16	4	$\frac{-1}{-4}=-\frac{1}{4}$
21.	$\sqrt{\frac{36}{64}}$	2	40	0	34	15	1	Reducing error

TABLE 1—(*continued*)

Rank in Difficulty (2nd Test)	Type of Item (from 2nd Test)	Errors on First Test				Errors on Second Test		
		Alg. Class 29 Fresh.	Gen. Math. 89 Fresh.	Ana. Geom. 6 Sophs.	Per Cent of 124 Missing Item	Per Cent of 61 Missing Item	Alg. Class 23 Fresh.	Error Made Most Frequently on Each Item
22.	Write 4.7% as a decimal	6	32	0	30	15	2	4.7
23.	Write $\frac{2}{3}$ as a decimal	0	13	0	10	13	2	.66
24.	$\left(\frac{\sqrt{7}}{9}\right)^2$	6	53	0	47	13	0	$\frac{7}{9}$
25.	7% of $\frac{6}{11}$	6	35	0	33	13	3	Miscellaneous
26.	(87.5)(.0908)	3	25	2	24	13	3	Carrying in addition
27.	Write .003 as a common fraction	2	11	2	13	11	2	$\frac{3}{100}$
28.	Change $\frac{4}{5}$ to per cent	4	19	1	19	11	2	.80
29.	(9−2)(4−5)	4	24	1	23	10	0	+7
30.	$\frac{15}{37}-\frac{23}{37}$	4	35	1	32	10	1	$\frac{+8}{37}$
31.	$\frac{5}{12}-\frac{5}{8}$	3	14	1	14	10	2	Error in sign
32.	16% of 89	3	17	0	16	10	1	Computational error
33.	$\frac{13}{63}$ times 0	2	39	0	33	8	0	Impossible
34.	$\frac{8}{19}\div\frac{7}{19}$	3	20	0	18	8	1	Miscellaneous
35.	$(53)\frac{6}{7}$	6	18	0	19	8	2	Computational error
36.	$(.3)^2$	5	56	2	50	7	0	Decimal
37.	$72\left(\frac{7}{8}\right)$	0	11	0	9	7	2	Computational error
38.	$\frac{48.8}{.08}$	6	31	0	30	7	0	Placing decimal
39.	4^3	0	27	0	22	5	3	Miscellaneous
40.	$8(4\frac{1}{2}+3)$	8	21	2	25	3	0	Miscellaneous
41.	$.92\div\frac{4}{7}$	11	29	1	33	3	1	Miscellaneous
42.	$\frac{29}{13}\div\frac{29}{7}$	2	22	0	19	2	1	Miscellaneous

The group of most interest and concern included under Table 1 is the Algebra Class which was composed entirely of males with high school majors in mathematics who intended to pursue mathematics or science in college; only about one-fourth of the General Mathematics Group had any intention of taking another mathematics course. The chief differences in mathematical backgrounds of these two main groups were that the Algebra Class averaged over a year more of high school mathematics than the General Mathematics Group and that the General Mathematics Group was composed almost equally of men and women. While it was impossible to make certain that the 124 students, including six sophomores, who took the *First Test* were equivalent in ability to the sixty-one of the 124 who took the *Second Test*, examination of the composition of the two groups disclosed no strong reason for assuming otherwise.

In general the data of Table 1 seem to indicate that students with majors in high school mathematics will do better on a test of this type measuring number techniques than an unselected group of students, for the average number of errors made on the *First Test* by the Algebra Class was 10 as compared with 17.7 for the General Mathematics Group. The results of the two tests taken together tend to show that the usual course in algebra or mathematics for general education does not prepare a student to cope with the arithmetic and the work with radicals that he will meet in the traditional course in plane trigonometry. Also, errors with certain types of items give evidence of persisting out of proportion to their apparent difficulty. A good example is Item 1, involving the squaring of a binomial surd. This type of problem was treated in the algebra textbook used and its solution was stressed by the instructor in the semester's work; yet it appears at the top of the list as missed most frequently on both tests with little apparent improvement from test to test. Although the General Mathematics Group could hardly have been expected to learn the expansion of a binomial surd, the Algebra Class did have sufficient opportunity. Simple items like numbers 1, 2, 6, 7, 8, 11 and 27 continued at the end of the semester to cause trouble in excess of their apparent difficulty, and comparison of the percentage of errors on these items in the two tests shows either little improvement or actual retrogression. A partial explanation for the lack of improvement on Item 2 lies in the fact that the algebra textbook contained no problems similar to it. Indeed, the only items from both tests similar to problems in the textbook were numbers 1, 6, 18, 21, and 39. On the other hand improvement on items like number 2 could have been expected only from the Algebra Class since the other students had only one day of instruction on radicals. All arithmetic items ex-

cept radicals were treated much more thoroughly in the General Mathematics classes than in the Algebra Class.

Particular attention should be called to the following items which were missed by the Algebra Class more frequently on the *Second Test* than might have been expected from college freshmen just completing a course in algebra: 1, 2, 5, 7, 8, 10, 12, 13, 14, 15, 19, 20 and 39. At least part of the reason for the continued errors on these items lies in the already mentioned failure of the algebra textbook to provide instructional material covering the items. This shortcoming of the textbook is brought out more strongly when cognizance is taken of the fact that many of the items on these tests are, with some sound reason, judged to be prerequisite to success with plane trigonometry and, therefore, to success in college mathematics generally.

In Table 1 the last column, containing the typical error made on each item of the *Second Test* at the end of a semester's work, reveals an apparent lack of understanding which in some cases is appalling. Most of the errors made were those in procedure, resulting from a failure to recognize the order of steps in the solution of a problem or inability to perform the last step in completing the problem. Obviously, many of the students had no realization of several of the methods of putting a fraction or radical into its simplest form.

A tabulation and count of certain types of errors made by all sixty-one students on the total of forty-two items follows: error in rounding, 10; error in copying, 11; error in reducing, 11; items omitted, 29; error in arithmetic computation, 46; error in placing the decimal, 64. From this count it appears that the sixty-one students as a group averaged more than one error each in placing the decimal in the answer and about three-fourths of an error each in arithmetic computation.

Further examination of Table 1 reveals contrasts (some to be expected) between the achievement of these different groups of students. In Table 2 the ten most frequently missed items for the three groups on the *First Test* are arranged in the order of decreasing frequency of error. Under the Total Group seven of the ten errors listed in this table were made with radicals, while under the Algebra Class only three errors of the ten were made with radicals. This fact may be taken as some evidence that radicals cause the most difficulty in topics of the type included in this test.

In the trigonometry course offered at Pensacola Junior College during the second semester remedial instruction was even more rigorously applied in order to try to eliminate the cause for errors with number techniques before the class proceeded into the trigonometry textbook, for such extensive weaknesses as are twice revealed here

demand a program pursuing a goal of adequate remedial instruction along with a carefully planned integration of the conventional subject matter contained in the traditional textbook.

TABLE 2

	TOTAL GROUP	ALGEBRA CLASS	GENERAL MATHEMATICS GROUP
1	$(\sqrt{6}-\sqrt{7})^2$	$\frac{7.11}{0}$	$(\sqrt{6}-\sqrt{7})^2$
2	$\frac{\sqrt{1-\frac{1}{4}}}{4}$	$(\sqrt{6}-\sqrt{7})^2$	$\frac{\sqrt{1-\frac{1}{4}}}{4}$
3	$\frac{7.11}{0}$	Write 7.8% as a common fraction	$\sqrt{2-\left(\frac{\sqrt{5}}{4}\right)^2}$
4	$\sqrt{2-\left(\frac{\sqrt{5}}{4}\right)^2}$	$\frac{\frac{1}{2}-\frac{1}{4}}{\frac{3}{4}-1}$	$\sqrt{\frac{3}{25}}$
5	Write 7.8% as a common fraction	$\frac{\sqrt{1-\frac{1}{4}}}{4}$	$\frac{6+3\sqrt{2}}{3}$
6	$\sqrt{\frac{3}{25}}$	What per cent of 50 is 13?	$\frac{7.11}{0}$
7	$\sqrt{36+64}$	$4.798 \div 8.9$	$(.2)^3$
8	$(.2)^3$	$.97 \div \frac{5}{9}$	Write 7.8% as a common fraction
9	$\frac{6+3\sqrt{2}}{3}$	$.67 \div .0097$	$\sqrt{36+64}$
10	$\left(\sqrt{\frac{5}{4}}\right)^2$	$\sqrt{36+64}$ and $\sqrt{\frac{3}{25}}$	$\left(\sqrt{\frac{5}{4}}\right)^2$

In an attempt to meet the same goal in all mathematics classes during the first semester a series of tests and exercises was fashioned. Two questions were used as criteria in the selection of the items incorporated:

1. Does the item point up a frequently occurring deficiency in the mathematical background (arithmetic, simple algebra, plane geometry) of freshmen in college?

2. Is the item, as well as judgment can determine, prerequisite to success specifically with plane trigonometry or other elementary college mathematics and, therefore, at least incidentally necessary to success with any college mathematics or science?

On the basis of these two questions the author assembled about 900 items for original presentation to his students in mimeographed form. On them no distinction was made between test material and remedial material on the assumption that a good test item would be a good item for instruction and that time would be saved in so using it. Each item was in itself a test of a concept important to success, and mastery of that item by the student, after he had tested himself on it, was the first step toward remedying his deficiency. The list might best be described as "the core of the minimum essentials for plane trigonometry."

In order to test awareness of procedure in simplifying a mathematical expression, the directions for these exercises were worded with the intention of meaning, "Perform the operations indicated by the mathematical notation and symbols in order to obtain the answer or to simplify." Many of the items covered types of high school and college student errors on which counts have been made by the author over a period of years. Others were selected because they have been declared by other teachers in published articles to be troublesome to college freshmen. All together the items offer the instructor the means of a rather thorough diagnosis of the weaknesses of his class.

One strong advantage of the diagnosis is that it can be performed entirely by the students themselves in a relatively short time. Answers are provided so that the student can correct his own paper and record his own mistakes. Of course he must be encouraged to be honest and exact in doing so. Faster and brighter students may be utilized in making the total count of errors for the whole class from the individual records. Experience has shown that students participate in these diagnostic exercises with spirit and interest.

An individual and a class sheet for recording errors is included with the tests and exercises. To serve as a guide in doing his studying each student records any errors he makes on his "Record Sheet." The master class record sheet displays the deficiencies of the class so clearly that the instructor can see exactly where to start teaching and what remedial measures ought to be adopted. The exercises were used diagnostically in this manner at Pensacola Junior College for the first week of the semester and at intervals thereafter.

To assist the student in correcting his weaknesses additional diagnostic tests and assignments in other books were given to him for supplementary drill on the type of exercise he missed most often on

the tests. In periods set aside for individual instruction those students in the class who intend to become teachers and who are also proficient in their mathematics may be used as volunteer, assistant instructors. All extra exercises completed by the student are recorded on his Record Sheet as an indication both of his industry and the work covered.

The large objective of the entire remedial program of instruction was to insure for each student, as the minimum essential for every course, the attainment of adequate preparation for the next higher course.

An attempt to draw conclusions from such tabulated test results as appear here may easily become a departure upon a voyage into the realm of conjecture, since all that is possible for certain is to state hypotheses which are deemed to fit the tables. Indeed, the bare table is the most accurate description of the situation behind the facts displayed. Nonetheless, the following are some of the more obvious inferences which might be made:

1. Many investigators have found that fractions are at the source of much of the difficulty that college freshmen have with arithmetic. Here is evidence that radicals cause more trouble than fractions and that the combination of fractions and radicals can be a high hurdle for the freshman student.

2. Many entering college freshmen do not possess the understanding of, or skill with, the elementary number techniques prerequisite to success in college trigonometry.

3. It is erroneous to assume that college freshmen will strengthen their deficiencies in mathematics without outside assistance or that their deficiencies will be eliminated through the usual instruction afforded by the ordinary mathematics course.

4. A remedial program is worth the time and effort and is to an extent effective, but even after considerable remedial attention students persist in making errors with certain types of problems—errors not warranted by the apparent difficulty of these problems.

5. The relative difficulty of key problems or concepts essential to preparation for advanced mathematics should be experimentally determined.

6. Stronger and more concrete remedial teaching methods for use with the most difficult and important concepts should be devised in order, if possible, to assure longer retention.

7. The traditional textbooks for courses in general mathematics and college algebra do not provide materials of instruction pertinent to the attainment of a mastery of the basic number techniques prerequisite to success with plane trigonometry.

8. Special diagnostic tests and remedial exercises should be de-

signed for use prior to a trigonometry course and fashioned exactly to fit the trigonometry situation.

9. A remedial program for all freshmen in all college mathematics should be carefully planned to include the following:

a. Administration of a group diagnostic test.

b. Administration to each student where needed of additional diagnostic tests especially in the arithmetic of those areas in which the group test shows him deficient.

c. Construction of remedial exercises for use with the student deficient in trigonometry.

10. A student who enters college with the intention of preparing for engineering or some other field requiring higher mathematics cannot be expected to succeed with higher mathematics or the sciences of chemistry or physics when he lacks facility in solving correctly such problems as "Write 4.7% as a decimal" or "3−4/3−7". Either he should be dissuaded from entering an engineering course or a remedial program should be made available that will enable him to succeed.

11. In the study of mathematics the effect of errors is cumulative. Failure of a student to master a previous concept often makes it impossible for him to master a subsequent one. An example is found on the *First Test* on which 22% missed 4^3 while 50% missed $(.3)^3$. Of the 50% who missed the second item here it is probable that 22% missed it because they could not do items like the first one.

12. There are several questions which merit research investigation.

a. In mathematics textbooks after the elementary school, what space at all is allotted to items and topics of the kind which appear in the tests reproduced in this article?

b. What provision has been made for instruction in topics such as these beyond the elementary school?

c. Should colleges generally take greater responsibility than they do for rectifying deficiencies in their students' mathematical backgrounds?

Excellence is an art won by training and habituation. We do not act rightly because we have virtue or excellence, but we rather have those because we have acted rightly. We are what we repeatedly do. Excellence then is not an act but a habit.—ARISTOTLE

Were half the power that fills the world with terror,
Were half the wealth bestowed on camps and courts,
Given to redeem the human mind from error,
There were no need of arsenals and forts.

—HENRY W. LONGFELLOW

STATIC FORCES FRAME*

JOHN A. DOUGHTY
University of Arkansas, Fayetteville, Arkansas†

This force frame is home-made and of materials readily available to any teacher. All parts can be purchased, if necessary, for approximately two dollars, but it replaces almost a hundred dollars worth of commercial static forces equipment in a satisfactory manner.

When supplied with the center board and ring, the apparatus can be used to verify experimentally the laws of composition and resolution of forces, and to illustrate vector addition and subtraction. Weight hangers and strings passed over the ball-bearing rollers may be used, or spring balances may be hooked to the dowel pins. If enough weights are not available, small cans of sand may be used and weighed on a beam balance after equilibrium has been obtained. The angles may be determined from the markings at the holes if speed is desired and approximations are enough. More accuracy can be attained by removing the center stick and marking the positions of center and the strings on a piece of paper, or by placing a piece of polar coordinate paper on a cardboard backing and placing over the center pin.

By adding a strip of wood in which has been drilled several holes, the frame may be used as a non-concurrent forces apparatus, for the study of coplanar non-concurrent forces by either graphical or analytical methods.

Another strip of wood somewhat larger than before and notched so that it may be placed over the ball-bearing rollers, may be used as a simple-form truss, using either of the two standard demonstrations commonly used with this apparatus.

The frame may be used for many other purposes in the laboratory or for demonstrations where the use of such a suspension can be of value. For example, it can be used as a suspension for a simple harmonic motion spring, or for pulley demonstrations and experiments.

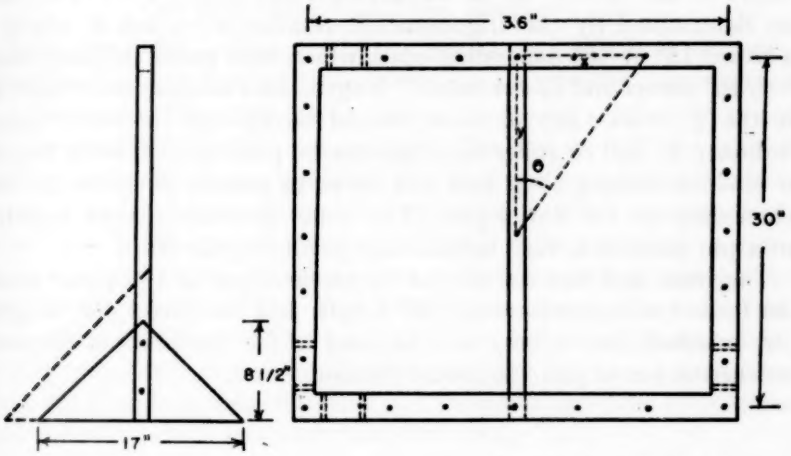
The frame is $30'' \times 36''$ on centers and is constructed of $1'' \times 2''$ pine, with plywood or metal corner braces. The removable center pole is $1''$ square and fastens to the $0°$ and $180°$ holes with $2''$ machine bolts (8×32) supplied with wing nuts for ease in removing. The center pin may be a nail or a $3''$ machine bolt. Standards are cut from $3/8''$ plywood and are drilled with two sets of holes for use in

* Exhibited at Eleventh Annual Colloquium of College Physicists, State University of Iowa, June 14–17, 1950.

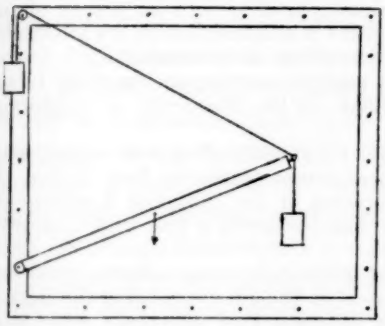
† Research Paper No. 939 Journal Series, University of Arkansas.

either of the positions shown in the sketch when fastened with machine bolts and wing nuts. The frame is drilled for use with either

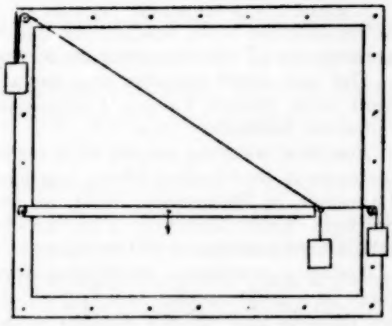
DESCRIPTION OF FRAME



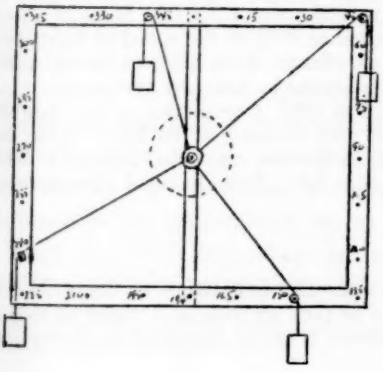
SIMPLE-FORM TRUSS 1



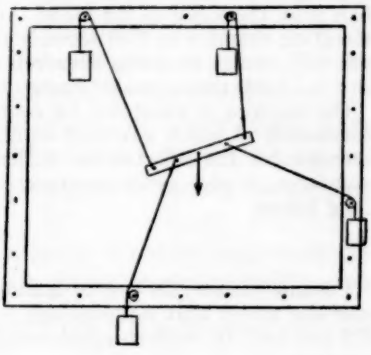
SIMPLE-FORM TRUSS 2



CONCENTRIC FORCES



NON-CONCENTRIC FORCES



dimension vertical, extending its usefulness as a suspension for general use.

Locations of the $\frac{1}{4}''$ holes at 0° (top center), 90°, and 180° are easily determined as the midpoints of the sides. Distances from these base points to the centers of the remaining holes placed at 5° intervals are determined by the trigonometric relation $x = y \tan \theta$, where y is either 15″ or 18″ depending upon which base point is being used. A 5/16″ dowel rod is cut into 3″ lengths and sanded to a taper to fit the $\frac{1}{4}''$ holes. Ten of these should be enough for each frame. Ordinary $\frac{5}{8}''$ ball or roller bearings can be purchased from a bicycle or machine supply shop and will serve to greatly decrease friction when used on the dowel pins. Two roller bearings placed together on a pin provide a very satisfactory pivot for the truss.

The truss and non-concurrent forces piece are of 1″ square wood, the former of approximately 30″ length and the latter, 12″ length. Fire-polished glass tubing may be used to line the holes in the non-concurrent forces piece to reduce friction.

GIANT ATOM SMASHER

A giant atom smasher, capable of producing protons with an energy of six billion electron volts, reached the halfway point in construction on the twentieth anniversary of the construction of the world's first atom smasher.

The new atom smasher is a bevatron, gigantic cosmic ray machine, being built with Atomic Energy Commission funds at the University of California radiation laboratory here.

The first working model of a cyclotron, a four-inch glass and sealing wax instrument that looked like a hip flask, was demonstrated by Prof. Ernest O. Lawrence in September, 1930, at the meeting of the National Academy of Sciences. Later that year Prof. Lawrence had operating a four-inch cyclotron which fired protons of 80,000 electron volts.

Today a ponderous 10,000-ton bevatron magnet is being mounted piece by piece in a great circular building which stands on the hill overlooking the Berkeley campus and rickety wooden structure in which Prof. Lawrence performed his pioneering experiments.

The great magnet will guide protons in a precise path over a distance greater than from the earth to the moon. After traveling about 300,000 miles in an accelerating chamber in 1.85 seconds and reaching 99% of the speed of light, protons will emerge from the bevatron with an energy of six billion electron volts. This is 75,000 times greater energy than produced by the first cyclotron.

The machine is scheduled for completion in 1952. Completion of the magnet, installation of much auxiliary equipment, and building of 10 MEV linear accelerator for the injector are still ahead. A similar machine, the three BEV cosmotron, is also under construction at the AEC Brookhaven Laboratory on Long Island.

Vacuum cleaner, for use in laundering rugs and upholstery at home, has an over-size motor that supplies high suction to pick up suds and water as well as dirt and lint. Its rubber-sealed metal reservoir is easily detached for convenient emptying.

ARTICULATING JUNIOR HIGH MATHEMATICS WITH ELEMENTARY ARITHMETIC*

LUCILLE HOUSTON
Oak Street Junior High School, Burlington, Iowa

This 1950 Convention with the theme "Frontiers in Teaching Mathematics and Science" affords an opportunity for us to inspect our own house with respect to past and present achievements and the possibility of future movements. The history of education is well known to all of you but it is important for my purposes to keep in mind the fact that the junior high movement is a comparatively new "baby" in the household of education. It came into being partially in an effort to bridge the gap between the elementary school years and the high school. The high school was losing many students through those who failed to continue beyond elementary school and by dropouts in the first years of high school due to lack of adjustment. In an effort to help these students and to encourage them to continue their schooling the junior high came into being.

Next let us turn our eyes toward what followed. In many instances educators accepted the idea so wholeheartedly that they started their junior high set-up immediately. In the majority of cases grades seven, eight, and nine constituted the junior high group. These grades were, in some cases, segregated in separate buildings, in some cases moved to a separate floor in one building, and in some instances the grouping was an imaginary thing only. This physical set-up was not the most important factor for us to observe, however. These junior highs needed teachers. Since educators had so abruptly fallen in love with the idea, teachers had no time to prepare themselves any differently than in previous years. Junior high teachers, even today, come —for the most part—from two backgrounds: those who have tended to enter junior high from an older elementary school pattern and the second group includes those who were trained for the old four year high school set-up and its traditional program. Education in its anxiety to get on the band wagon did not give teacher training institutions time to prepare for this approach to the problems of the adolescent years, nor have these institutions, in many cases, been quick to aid teachers who had already received their training but who, seeing the merits of such a proposal, were willing to prepare themselves for junior high work.

That picture is important to have in mind when we approach the problem of joining mathematical hands of elementary and junior

* Read before the Junior High School Group of the C.A.S.M.T. at its "Golden Anniversary" Convention in Chicago, November 25, 1950.

high work. There seems at present to be a wide divergence in terms of basic philosophy, of standards of work and achievement, and in methods of teaching and learning, the widest gap being in the latter area.

These differences are not insurmountable. However, their resolution will require that the heart of every teacher involved be interested in the accomplishment of the project. Until teachers want to work for such elements of arithmetic as concepts and information, principles and relationships, and understandings and judgments as well as abstract computations and textbook problems, functional competence will not be achieved—whether those teachers happen to be on the elementary, junior high or senior high level.

There was a time when the seventh grade mathematics teacher felt she had a right to expect certain abilities of her incoming students. Sixth grade students just were not "passed" without possessing them. Those were the horse and buggy days—in more ways than one. The psychology that dominated was that which warned teachers to teach every process in precisely the way that it would be used. Pupils were told "This is the way to do it" and then were drilled until they mastered it. A psychology that is much more acceptable in light of present knowledge tells us that we must look ahead to what we desire our pupils to know and then provide carefully graded experiences leading pupils from the point where they are, to the point where we wish them to be. We have since learned that it is much more important for the elementary teacher to lead her students to discover truths for themselves. I say that we have learned it but I am not sure we act as if we believe it is true—or accept it as being right. You know, perhaps we junior high people are not very thoroughly acquainted with what goes on in our own elementary schools! Maybe they have not invited our investigation but neither have we taken the initiative. 'Tis a far cry from what went on when we resided in those hallowed seats in grades four, five, and six. These youngsters are working with concrete materials. They are living in an activity school where discoveries are pupil-made rather than teacher-imposed. To be sure, the teacher is still there—but she is the foreman giving the pupils' work purpose and direction. The emphasis is upon understanding and as a result they probably *do* cover less material in many cases than we sometimes "think" we have a "right" to expect. This emphasis upon understanding seems to indicate that we should not expect students to use refined methods of adults upon entrance to junior high.

Consider the junior high student also. He is approaching or has reached the young adult stage—which means that he is neither child nor adult, wants the privileges of both groups and the responsibilities

of neither. He is contradiction personified. He is being torn between loyalty to his peer group and loyalty to society in general—these two, in his mind, being at odds with one another.

That is the situation and now what to do about it? As I have said before, I do not believe that it presents insurmountable problems. Professional equipment required by elementary teachers includes, among other things, a knowledge of all that which teachers of lower grades have taught. I propose that no less should be expected of junior high teachers. Some place during her period of training the prospective junior teacher should be given the opportunity to become familiar with the philosophy and teaching methods of the up-to-date elementary school. This need not be a time-consuming, drawn-out, laborious course—but rather one which will help the prospective teacher to better understand the student who comes to her from elementary school and which will prepare her to meet him at his level.

To a large extent the procedure to be followed in the early months of a child's junior high experience should closely resemble that of the elementary school. The student is not yet ready for abstractions and generalities. A few short weeks in the summer of a 12-year-old child cannot bridge the gap between the informal, helpful atmosphere of the elementary school and the formal traditional approach found often in the junior high.

Measurement affords a perfect opportunity for such an approach. It provides many possibilities for the pupil to make discoveries for himself. There are, too, innumerable advantages to such an approach. Children enjoy handling and manipulating measuring instruments. Their use is not new but that use is now to be extended. Since early elementary years they have measured objects with rulers. Now the precision of their measurement increases with the use of more finely graduated tools. Measurement problems from outside sources can be easily included in class work. Shop, home economics, and art work are all making use of measurements. Also many students have hobbies which involve this skill—model airplane building being one. These applications often require computations with fractions and decimals which demand greater proficiency than the student possesses. He then sees the sense in his learning a process. Progress is made from linear measure to angular measure. The two can then be blended in studying various shaped figures and discovering relationships between sides and between angles. Perimeters of various figures can be found with emphasis upon the effect of changing the length of the sides or upon observing what occurs when the perimeter is held constant while the sides are altered. Areas of rectangular figures can be found by dividing the figures into squares each one inch by one inch. A square inch should have more meaning to the

child after actually handling and building one or more for himself. And so this can be carried on—the amount of mathematics being used becoming as great as any teacher affords chances for her group. The student is advancing from handling concrete and semi-concrete materials to the place where he can make observations and generalizations of his own. The gradual approach gives the student a security which is invaluable and at the same time opportunity is afforded for increasing mastery of skills, and number relationships are being given consideration.

The work of seventh grade, naturally, involves more than measurement and the skills and relationships involved therein. Ratio is an important topic and the terminology is new to the junior high student. The meaning of ratio and an understanding of it can stem from the previous work, however. In comparing the length and width of a rectangle, ratio is involved as it is in comparing perimeters or areas of different figures.

Percentage is new to these students. Meaning can be lent to the introduction of it by means of figures divided into one hundred squares and also by relating it to ratio. Always the new is explained in terms of what the child knows and understands. Learning in advance of understanding cannot be permanent. Basic facts should not be learned before preliminary development of meaning. We do not want automatic response of facts taken on faith. We want to work toward automatic response of facts that have been discovered. This is not the job of the elementary schools alone. Junior high schools must build on the foundations laid in previous years. It is not a matter of re-doing or improving the work of grades one through six. Rather it is a job of extending learnings in junior high schools.

I feel that we can be safe in assuming that junior high teachers are teaching in that field because they are convinced that that is where they choose to be. There are too many trying problems and puzzling situations to be faced that are unique to this level for any sane person to remain there if he is not thoroughly sold on it. This is the thought that gives assurance that progress is now being made and will continue to be made toward articulation of junior high mathematics and elementary arithmetic.

As I see it this involves these items:

(1) A gradual shift from the informal methods of elementary school to more abstract thinking and generalizations.

(2) An understanding and appreciation of what has been taught in elementary work.

(3) A continued emphasis upon developing meanings and understandings, building always upon the foundations of knowledge that the student possesses.

(4) An acceptance of the fact that sixth grade students do not possess arithmetical abilities that make them functionally competent—that the job of providing this falls beyond the elementary level right into the lap of the junior high and possibly the senior high.

MODEL FOR ILLUSTRATING PROPORTIONS IN RIGHT TRIANGLES

ETHEL L. GROVE
1814 Tuxedo Avenue, Parma 29, Ohio

I. Construction

A. Materials

1. One stiff cardboard rectangle approximately 15″×20″.
2. One piece of similar cardboard approximately 8″×14″.
3. Cord or very fine elastic cord if available (about 9″).
4. Scotch tape, scissors, and pen and ink.

B. Steps in Construction

1. On the large rectangle construct a right triangle ABC with right angle C toward the top of the model. Sides of 8″, 15″, and 17″ make a triangle of convenient size.

MODELS FOR ILLUSTRATING PROPORTIONS IN RIGHT TRIANGLES

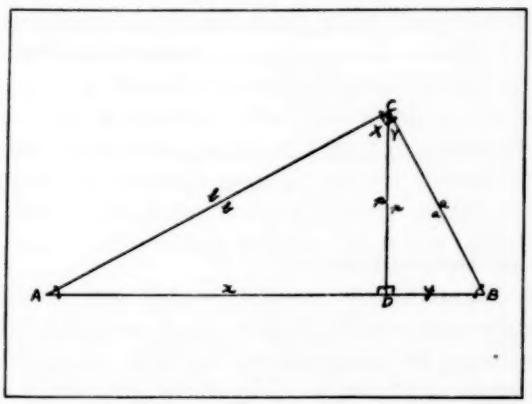


FIG. 1

2. Construct the perpendicular CD from C to the hypotenuse AB.
3. Outline this figure in ink and letter all vertices and sides outside the figure.
4. Copy $\triangle ACD$ and BDC on the other cardboard and cut them out.
5. Place these two small triangles on $\triangle ABC$ and letter all

vertices and sides on the inside of these triangles to coincide with the lettering on $\triangle ABC$. (Figure 1.)

6. While these triangles are in place on $\triangle ABC$ make small holes in each leg of $\measuredangle A$, B, and C about $\frac{1}{2}''$ from the vertex, insert cord or elastic through them, and tie the small triangles to the model. (These loops hold the small triangles in place for demonstration and at the same time make it possible to remove either one of them by raising it at D and slipping the other vertices from their loops. If the tips of the small triangles become too weak to hold well, wrap them in Scotch tape.)
7. Remove the small triangles, turn them over, and copy all side and vertex letters on the opposite side of the triangles.

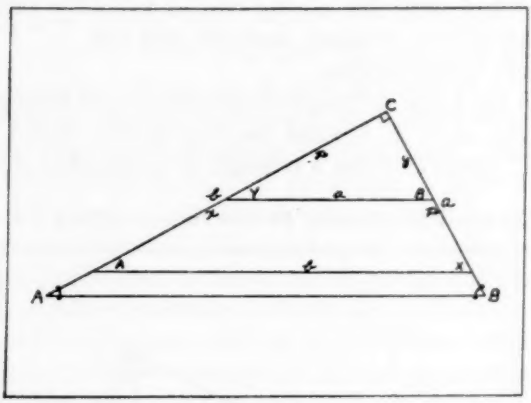


FIG. 2

II. Use

A. Teacher Demonstration

1. By removing the small triangles and turning them over against the model (Figure 2) or arranging them in other positions for comparison, the three proportions in a right triangle that are so difficult to visualize can be demonstrated.
   a. The two small triangles are similar to the original triangle and to each other.
   b. The perpendicular from the vertex of the right angle is the mean proportional between the segments of the hypotenuse.
   c. Either leg is the mean proportional between the hypotenuse and the adjacent segment.
2. The model should be left on a table where the students

may work with it after the demonstration to fix these relationships in their minds.

B. Pupil Experimentation

1. The similarity of the three triangles may be observed by preliminary experimentation, but the resulting proportions are not likely to be noticed.
2. Placing this model on the bulletin board or work table again at the end of the unit so that the pupils may review these relationships by individual investigation often helps to clarify their thinking.

MODEL FOR INTRODUCING MOTION PROBLEMS

ETHEL L. GROVE, CHARLES E. SCOTT, AND EWART L. GROVE
Cleveland, Ohio

I. Construction

A. Materials

1. One stiff cardboard rectangle approximately 15″×20″.
2. Six 3″×5″ scratch pads or pads of paper cut to about that size and stapled together.
3. A 5″ square of red, yellow, and green construction paper.
4. One strip of heavy paper approximately 4″×19″.
5. Scotch tape or glue, a sharp knife, and pen and ink.

B. Steps in Construction

1. On the cardboard rectangle arrange the six scratch pads in two rows as shown in the illustration, and attach the back of the pads to the cardboard by either Scotch tape or glue.
2. Above the scratch pads write the distance-rate formula so that each letter in it labels one of the three columns.
3. About 2″ above each column cut a slot slightly more than 5″ long.
4. With glue or tape fasten the strip of heavy paper on the back of the cardboard above and below these slots so as to form a pocket $1\frac{1}{2}$″ deep under each slot.
5. On the upper half of the red square write "GIVEN," on the yellow, "FIND," and on the green, "EQUATE."

II. Use

A. Teacher Demonstration

This model is a more convenient and colorful means of introducing the six-space chart system for analyzing motion problems than the commonly used skeleton chart with two rows and three columns that must be drawn on the blackboard for each problem. However, students should be urged to draw

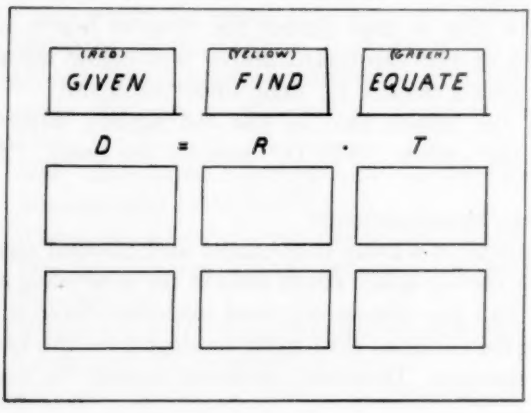
the simpler chart for each motion problem in their assignments.

1. Have students read the problem and decide what is required. Put the yellow tag in the pocket above that element, and on the pads below express its value in each of the two situations compared.
2. Determine which of the three elements is given for each of the two situations. Put the red tag in the pocket above that column and write the given values on the pads below.
3. Have students fill in both blanks in the remaining column by substituting in the D=rt formula the values already expressed in each row.
4. When these values are represented put the green tag in the pocket above them, find in the problem the relationship between them, and write the equation from this statement.
5. When the problem is completed the colored tags and the top sheets of the pads should be removed to prepare the model for the next problem.
6. The color of the tags may be emphasized in classes having difficulty with this type of problems. The red tag indicates the step in which most errors are made. The data used in this column must be facts given for each situation separately, not a value for the two situations combined. Finally, placing the green tag after the last column is completed by the formula, indicates that they cannot proceed with the equation until those values are represented and available for use in the equation.

B. Pupil Review

This model should be left on the bulletin board throughout the unit as a reminder when motion problems occur.

MODEL FOR INTRODUCING MOTION PROBLEMS



INSIDE THE ATOM

IV. FUNDAMENTAL PARTICLES

BARBARA R. BALZER
Fieldston Lower School, 3901 Greystone Ave., New York 63, N.Y.

We have been introduced, by this time, to several very small particles—most of them smaller and lighter than atoms. One of them was named by Johnstone Stoney and discovered in cathode rays by J. J. Thomson. It is the electron Another kind of particle we met as the "bullets" that Lord Rutherford used to shoot at nitrogen atoms. These "bullets" we called *alpha particles* and we know that Rutherford eventually proved them to be the nuclei of helium atoms. The protons and the neutrons that Niels Bohr said existed in the nuclei of atoms are familiar to us.

There are other particles, also smaller than atoms, that have been discovered more recently and are being used in the latest atomic experiments. Some others of these particles, which are called sub-atomic because they are smaller than atoms, are: positrons, deuterons mesons, photons, and neutrinos. Because such a variety of sub-atomic particles is bound to be confusing, let us take inventory of these particles before we discuss them further. If we can classify them according to their mass, according to the electrical charge they carry, according to where they come from and what they do, we will be better equipped to go on to talk about the atom-splitting experiments of the past ten years.

Let us start with the one whose name we have heard the most often—the electron. The electron was the first sub-atomic particle that men were able to recognize and to measure. It was J. J. Thomson, the English physicist, who first showed that the glow sometimes present when an electric current is passed through a vacuum tube is really made by a stream of charged particles passing from one end of the tube to the other. Not only did he show that each particle in the stream carried a charge, but he was able to prove that the charge was a negative one. He even weighed the particles!

This sounds mysterious. How can one weigh what one can't even see? (For the glow in the tube was only a sign that the electrons were there—Mr. Thomson was not seeing the electrons themselves.) It is not so mysterious if we remember that it is easier to change the course of a stream of rubber balls moving through the air than it is to change the course of a moving freight train. When a moving object is heavy, it takes a lot of force to pull it out of its path, but when it is light it can easily be pushed or pulled from its course. By measuring the magnetic force required to change the course of the charged particles in the tube, Mr. Thomson could measure their

mass. They turned out to be much lighter than anything ever known. The lightest thing previously known was an atom of hydrogen. These charged particles weighed only one eighteen hundred fortieth as much as a hydrogen atom.

Of course it was lucky for Mr. Thomson that the particles were charged and that he was able to find out how fast they were moving. Only a particle carrying an electric charge would be deflected from its course by a magnet. By the direction in which the particle turns from its course when a magnet is placed near by in a certain position, it can be learned whether that particle carries a positive or a negative charge.

We can say, then, that the mass of an electron is almost zero. We can also say that an electron means the same as one negative charge. In fact, electrons are sometimes called *negatrons*. Where do we find electrons? Beta rays are made of a stream of electrons moving at a tremendous speed. Electrons are the particles in the outer rings of the atom. They correspond to planets in Bohr's solar system.

For a long time, protons and electrons were the only fundamental particles that scientists needed to imagine in order to explain the behaviour of the elements. But, using only these two particles, scientists could not explain how some elements could be electrically neutral and yet weigh as much as they did. Then, in 1930, a particle was discovered that helped to answer this question.

In 1930, two German scientists, W. Bothe and H. Becker, discovered that a very penetrating ray, capable of passing through several inches of lead, was given off when alpha particles were shot at the light metal beryllium. They thought that this ray must be a new kind of gamma ray, possessing great energy. J. Chadwick, following a hint of our old friend, Lord Rutherford, was experimenting in England two years later. He was looking for a particle that Rutherford had predicted and had named *neutron*. Chadwick discovered that the Bothe-Becker rays were made of particles with masses as great as the masses of protons. Unlike protons, they were electrically neutral, and therefore they fitted Rutherford's prediction of the neutron. Since the neutrons were as heavy as protons, yet neutral electrically, it was decided that they were probably made of an electron and a proton closely tied together. It was supposed that neutrons produced when alpha particles bombarded beryllium metal came from the middle of the atoms, and that it was neutrons which accounted for the extra weights of some atoms.

A neutron, then, is probably made of a proton and an electron in close combination. It has a mass as large as the mass of a proton, but carries no electrical charge. Neutrons are found in many places—in the nuclei of atoms and in the Bothe-Becker "rays" given off

when beryllium is bombarded by alpha particles. Indeed, they are given off in many nuclear transformations. Neutrons are doubly useful in bombarding other atoms in disintegration experiments. Because they carry no electrical charge, it is much easier for them to get to the nucleus of an atom—for the nucleus of an atom is in part a cluster of positive charges and will repel any particle that is positively charged. Their large mass gives them great energy when they hit a target.

Alpha particles were the first particles used in bombarding nuclei. They, you will remember, were found to be the alpha rays that the Curies discovered were given off from radioactive elements like radium and thorium. It was Rutherford who discovered that an alpha particle is the same as the nucleus of a helium atom. The helium atom has two protons and two neutrons in its nucleus, with two electrons in its outer ring to balance the two positive charges of the proton. When those two electrons are somehow removed, leaving only the nucleus, the nucleus has a mass about four times as great as the mass of a single proton, and two positive charges. (Remember that the two neutrons do not carry electrical charges.) Alpha particles are equally useful as bullets for bombarding because of their large mass. It was with accelerated alpha particles that Lord Rutherford changed the nitrogen nucleus to an oxygen nucleus.

We now have electrons (or negatrons), protons, neutrons, and alpha particles accounted for. We might also say that we have identified two of the three kinds of rays given off by radioactive materials, for alpha rays proved to be made of alpha particles, and beta rays proved to be streams of electrons. The third kind of rays, gamma rays, does not consist of particles at all, but of tiny bundles of light energy. Gamma rays are the same as X-rays. The little bundles of light energy composing them are not particles at all, but have a name that suggests that they might be. They are called photons. A photon must have a slight mass in order for it to possess any energy at all, but this mass is so small that it may be considered zero. A photon carries no electrical charge.

For the discovery of the deuteron, science depended upon the spectroscope. The spectroscope is an instrument used to study the light given off by atoms of various elements under certain conditions. Three scientists, H. C. Urey, A. M. Murphy, and F. G. Brickwedde, were studying a photograph they had made of the spectrum of light given off by the element hydrogen. These men knew that the light given off by hydrogen would show a red line when passed through a spectroscope. They observed this hydrogen line in their photograph, but they also observed a faint line a little to one side of it. By measuring the distance of the faint line from the red line of the

hydrogen, they were able to determine that they had found a new kind of hydrogen which would combine with the same elements as ordinary hydrogen, but which weighed more. When it combined with oxygen to form water, it would form a kind of water which was heavier than ordinary water. This heavy hydrogen was named *deuterium*.

Scientists reasoned that deuterium must have all its extra weight in its nucleus, and, by using the same method we have already described, they measured the nucleus of a deuterium atom, with the electron taken away from the outside. They discovered that the nucleus of deuterium must be made of a proton and a neutron. The heavy hydrogen nucleus would then have a mass equal to about that of two protons, and would carry one positive electrical charge. This nucleus is called a deuteron or deuton. It is useful in bombarding because its mass is greater than the mass of an ordinary hydrogen nucleus, or proton, and hence it has more energy when it is in motion.

Another fundamental particle, the positron, was discovered through the study of cosmic radiation by Carl D. Anderson and R. A. Millikan. In 1930 these two men were studying the tracks made in a Wilson cloud chamber by the particles given off by materials which were struck by cosmic rays. They discovered tracks of negatively charged electrons moving at very high speeds, but they also observed some tracks of particles that carried a positive charge, judging from the direction in which they were deflected in a magnetic field. A lead barrier was placed in the path of some of the particles to test if they would be deflected in the same direction when they passed through the barrier. If they were deflected in the same direction, it would prove that they were really positively charged and not just negatively charged electrons travelling in the opposite direction from the other electrons in the photograph.

In 1932, photographs of the cloud chamber tracks of these particles before and after they had passed through lead barriers, proved that they must be positive electrons—particles with an exceedingly small mass and a positive electric charge. Then, when scientists examined cloud chamber photographs that had been taken before 1932, they discovered that there were positron tracks in those photographs, too—they had just not been recognized as positron tracks.

Positrons are usually produced by cosmic rays, but they can be produced by gamma rays and by the radiations generated when alpha particles are allowed to strike beryllium. Positrons are peculiar in that most of them last only about a billionth of a second. For there are many more electrons in the universe than there are positrons, and each time a positron and an electron meet, their charges cancel

each other, and their very small mass is changed into energy. This energy, the energy caused by their combination, is called "annihilation radiation" because the electron and the positron annihilate each other's mass when they combine.

The Nobel Prize Committee of 1936 considered the discovery of the positron important as an advance in the field of physics. They awarded Carl D. Anderson the Nobel Physics Prize in 1936.

Less than a year later, Mr. Anderson discovered a new particle in his cloud chamber photographs of cosmic radiation. From the shape and the size of the track the particle made, it seemed to have the same negative charge as an electron, but a much greater mass. At first this particle was called a "heavy electron." Later many scientific writers called it a barytron. Some physicists have suggested that it be called a Yukon, after the Japanese scientist, Yukawa, who had predicted its existence. However, it is usually called a mesatron, and sometimes "meson" for short. The name ***mesatron*** means "in-between" particle.

The heavy electron was so named because its mass did not seem as small as the mass of an electron nor as large as the mass of a proton. It seemed, from the observations of its track in cloud chambers, to weigh about two hundred times as much as an electron. Since the original discovery of the mesatron, some workers have discovered heavy positrons, mesatrons with positive charges. Many scientists now think that mesatrons can be either positively or negatively charged and that perhaps some of them are electrically neutral. Some scientists think that they do not have any set mass, but that the mass when they are at rest may depend upon how fast they have moved before they came to a stop. Scientists *do* know that a mesatron can travel through three feet of lead. They know that mesatrons move very fast and exist, on the average, for only about a millionth of a second. Some scientists think that mesatrons do not start out, in cosmic radiations, as separate particles, but result from the breaking-up of protons.

The scientist, H. Yukawa, predicted in 1935 that a particle about the size of a mesatron existed. He predicted that this particle would be unstable. It would disintegrate, obeying the laws of radioactivity which govern the disintegration of radium and thorium, into a normal electron and a neutral particle. He said that the half-life of this particle, called a Yukawa particle, would be about a millionth of a second. The neutral particle, which would be a product of the disintegration, has been named a neutrino. No way is now known by which a neutrino could be detected. Because it would be electrically neutral, it could not be deflected in a magnetic field, nor would it cause an ionization in a cloud chamber so that a picture

might be taken of its track. Its mass would be much smaller than the mass of an electron—so small that it would not have an observable effect even if it made a direct hit on the nucleus of an atom.

During the past few years, scientists have wondered whether the mesatron might be the particle which Yukawa predicted. It has about the same uncertain mass. From the time of its discovery, the mesatron has had all the characteristics which Yukawa predicted, except one—the ability to disintegrate. In the past years, scientists have seen definite signs that the mesatron is also radioactive and does, therefore, disintegrate.

Because this inventory of fundamental particles is complete for today, does not mean that it is finally complete. There was a time, not twenty years ago, when only electrons and protons were necessary in the imaginations of scientists to explain the behaviour of atoms. Now they have imagined and proved indirectly the existence of neutrons, positrons, deuterons, photons, and mesatrons. They have even imagined the neutrino! But if you hear of a strange new particle called a nucleon, don't let it upset you. "Nucleon" is only the name which some scientific writers give to all the particles which may come from the nuclei of atoms.

EDUCATIONAL CHANGES AT M.I.T.

Full acceptance of a broader educational mission involving concepts of a university with new but limited objectives that call for pioneering and leadership, is recommended in the report of a survey recently completed by a committee of the faculty of the Massachusetts Institute of Technology.

The survey was carried out by the Committee on Educational Survey which was appointed in 1947, at the request of the Institute's president to review the state of education at M.I.T. and re-examine the principles of education that have guided academic policy at the Institute for almost ninety years. Its task over the past two years has been to determine whether these principles are applicable to the conditions of a new era emerging from social upheaval and the disasters of war.

The recommendations of the committee call for new experiments in education and new exploration into the unknown involving vision and leadership of a higher order, not only in engineering, but in the natural sciences, the humanities and social sciences, as well as in architecture and city planning.

The committee's report discusses the educational philosophy developed at the Institute, the improvement of professional education, a broader educational mission, sponsored research, and organization of the faculty for greater unity and effectiveness.

In making its recommendations the committee expresses its belief that this goal must be achieved without departing from the philosophy of limited objectives that has contributed to the strength of the Institute in the past.

A lie stands on one leg, truth on two.—BENJAMIN FRANKLIN.

HOW MOVEMENTS OF IMPROVEMENT HAVE AFFECTED PRESENT DAY TEACHING OF MATHEMATICS*

E. R. Breslich
The University of Chicago, Chicago, Illinois

Mathematics Fifty Years Ago

Since the turn of the century far reaching changes have taken place in the world: changes in the balance of power of nations, in communication, in transportation, in industry, in the work we do, and in the homes we live in. A new world has been created. Naturally the schools also have changed; the curriculum has changed; the pupils have changed; and methods of teaching have changed. As new subjects began to compete with the older for a place on the curriculum the older had to change or yield their places. No subject could remain standing still while the entire school organization was moving forward.

As in all subjects there have been far reaching changes to improve the teaching of mathematics. They have been brought about slowly, but as we now look back over the past five decades we are aware of a steady progress of improvement of the mathematical curriculum and of the teaching procedure. This has been the result of a great deal of thought and labor by those who assumed leadership. The practices of today are the outcomes of the proposals of the leaders of yesterday. They are the work of many men and women who from time to time have reexamined the mathematical offerings and the methods of teaching, to retain that which was good, to indorse some of the new, and to eliminate the obsolete.

At the close of the century we find a rigid mathematical curriculum. Courses were designed for pupils who wished to prepare for college and who contemplated entering the professions, for future surveyors and engineers. But the school population increased, and adjustments had to be made to provide education not only for the selected few but for all pupils. A curriculum had to be developed which would be attractive, suitable and profitable to all. Changes also were necessary in the prevailing teaching procedure. They were brought about by a number of movements for improvement which have affected the present day curriculum and methods of teaching mathematics.

The Movement of Correlation

Traditionally the content of mathematics taught in high schools

* Read before the Mathematics Section of the C.A.S.M.T. at its "Golden Anniversary" Convention in Chicago, November 24, 1950.

was organized into separate disconnected courses: arithmetic, algebra demonstrative geometry and trigonometry. Each was studied intensively to the exclusion of the others. When the pupil "Finished" a course and had received credit for it he felt that he should not be held responsible for any deficiencies which appeared in a later course. The same attitude prevailed among many teachers. If arithmetic deficiencies appeared in algebra the teacher did not consider it his duty to interrupt the study of algebra to teach arithmetic. In demonstrative geometry he avoided the use of algebraic symbols and methods, and much of the algebra taught during the first-year was forgotten from disuse during the second.

At the turn of the century many administrators and teachers of mathematics had become skeptical as to the traditional arrangement of the mathematics courses, and felt that the time had come for a reconstruction. A similar feeling had developed in England, Germany and France. In 1902 interest in the problem was stimulated by an address "On the Foundations of Mathematics" by Professor E. H. Moore of the University of Chicago. He advocated the radical step of abolishing the prevailing "water tight compartment" organization by correlating the various mathematical subjects so that each division could illuminate and supplement the others. The courses were to continue to be designated as algebra, geometry and trigonometry, but geometry was to be used in algebra to clarify concepts; and algebraic notation and processes were to replace the clumsy notation of geometry. Some of the simple and useful concepts and principles of the upper courses were to be moved downward into the lower courses. In 1911 The Committee of Fifteen recommended that the concepts and abstract principles of algebra be made clear by the use of simple geometric illustrations. Thus the movement of correlation was gaining. It has persisted to this day and has grown to an extent never hoped for by those who first advocated this type of reconstruction. Geometry is now used freely in algebra, while algebraic symbols and processes are employed whenever they are advantageous to the learner.

Movement of General Mathematics

Closely related to the movement of correlation is the movement for *general mathematics*. The term designates a course so organized as to draw its materials and topics from the various mathematical subjects: arithmetic, elementary algebra, informal geometry and numerical trigonometry. It places much emphasis on applications, especially those taken from activities of every day life. It is concerned with graphical representation and simple formulas and equations. In the first decade a similar movement had made considerable progress in

the sciences, and during the second decade textbooks in general science appeared. In mathematics the movement progressed more slowly. There was much opposition by high school teachers, college professors, and publishers. Also the college entrance examinations which determined largely the instructional materials for high school courses did not accept general mathematics. Not until 1935 did the College Entrance Examination Board modify its attitude by proposing a new type of examination. In the meantime a trend had developed to teach general mathematics to "slow" groups of pupils, vocational classes and non-college classes. A stigma was thereby attached to general mathematics, and the movement which had grown during the first decade started to decline.

A new impetus was given by the development of the new junior high schools, and at the beginning of the third decade the new type of organization was well on the way. General mathematics has made possible a better psychological arrangement of subject matter, a better chance for establishing understandings and an enriched course filled with practical and social applications. Interest is more easily aroused; wasteful reviews are diminished; and the pupil's resourcefulness in attacking and solving problems is increased. It has bridged the serious gaps which long had existed between elementary and high schools mathematics.

In 1923 the National Committee on Mathematical Requirements proposed an outline of general mathematics for grades 7, 8 and 9 of the junior high school. In 1941 the Joint Commission went one step farther by submitting an outline for grades 7, 8 and 9 suitable to any school system, not necessarily junior high schools. The Commission on Post-War Plans in 1944 recommended general mathematics for a "second track" plan for all pupils who are not interested in the traditional sequence courses and whose special interests are not provided for by courses in shop mathematics, vocational mathematics and commercial arithmetic.

Today there is as much interest in general mathematics as ever. The junior college too has become concerned about it, since in 1940 the Joint Commission recommended a "general course of not less than a year for the terminal type of student in the junior college."

Objectives of the Teaching of Mathematics

Originally the major purposes of high school mathematics were: acquisition of valuable information, of manipulative skills and of facility in solving problems; preparation for future vocations or professions; and training for leadership in the community. It was commonly believed that pupils automatically derived considerable mental training from the study of mathematics. Having been taught to

reason logically in mathematical situations they were supposed to be able to reason logically in non-mathematical situations. By doing assigned home work day after day they were expected to develop efficient habits of study. Understanding of relationships in geometric forms studied in the class room was assumed to enable them to enjoy the beauty of forms found in nature, art and architecture.

The validity of such assumptions was being questioned when experiments seemed to indicate that if these values claimed for mathematics were attained by the pupils at all this happened only in a small degree. However, later experiments gave evidence that the extent to which abilities developed in mathematical situations would transfer to non-mathematical situations depends on the type of teaching. If the pupil is to acquire correct habits of study he must be taught how to study. If he is to develop problem solving ability it is not sufficient to make him solve numerous problems but he must be given instruction in the technique of solving problems which he may apply to problems he meets in out of school life. Thus correct habits of study and problem solving ability must be made objectives of the teaching of mathematics in addition to others like mastery of subject matter and skills. To few teachers of the first decade the thought had ever occurred that one might teach pupils how to study.

These findings naturally raised the question of the objectives of the teaching of mathematics. The National Committee of 1923 formulated a list of objectives which included training in exact thinking, in ways of problem solving and in generalizing; development of power to reason, of habits of work and study, of thoroughness, and others. The committee classified the objectives of mathematics as disciplinary, utilitarian and cultural. Thus the movement for setting up specific objectives of the teaching of mathematics was given a start.

Disciplinary objectives are today no less important than the other two. History shows that the pleasure derived from establishing facts by processes of reasoning has been a great influence in the development of mathematics. Mathematics lends itself more readily to the development of the power of correct reasoning than any other subject. Formerly the teachers of geometry emphasized reproduction of the proofs given in the textbook. Today an important objective of that course is understanding of the nature of proof. A major objective of supervised study is to teach pupils how to study. In making his plans for the next day's work the progressive teacher today does not overlook the opportunities for contributing to the disciplinary objectives.

The utilitarian values of mathematics had become increasingly prominent during the first two decades. John Perry had advocated a trend away from teaching high school mathematics as "pure" mathe-

matics. He emphasized "applied" mathematics, especially the uses of mathematics in mechanical drawing, physics, chemistry and engineering. Usefulness and practicability were depended on to appeal to the pupils. The movement to teach the type of mathematics that was useful and needed by the pupils continued to increase. In 1923 the National Committee recommended for Ninth Grade Mathematics the mathematical training that will be most useful. The Joint Commission in 1940 asserts that mathematics is important in education because the citizen of today uses a considerable amount of mathematical knowledge in the activities and experiences of everyday life. The Progressive Education Committee stresses the importance of mathematics because it makes contributions to the aspects of living. In 1944 the Commission of Post-War Plans makes "mathematical competence" an objective of teaching on account of the needs of the major fraction of the high school population. The Sixteenth Yearbook of the National Council of Teachers of Mathematics in 1942 submitted a comprehensive list of the uses of mathematics. Finally, the Guidance Report of the Commission of Post-War Plans in 1947 describes the following uses:

1. Mathematics for personal use at home and in everyday activities.
2. Mathematics used by trained workers.
3. Mathematics for professional workers.
4. Mathematics in industries.

Thus, from the beginning of the century to the present time the trend has been to emphasize usefulness of mathematics in and out of school life, because the citizen in general needs it and because the school should prepare pupils to meet this need.

There has been increasing attention to the cultural objectives. The National Committee of 1923 lists the following: appreciation of beauty of geometric forms in nature, art and industry; ideals of perfection as to logical structure; appreciation of the power of mathematics. To this the Joint Commission adds: understanding of important aspects of the world. The Educational Policy Commission in 1938 mentions two cultural objectives: enjoyment of the learner and appreciation of the cultural values. Mathematics is to be so taught as to lead the learner to a realization of the far reaching contributions the subject has made and is still making to general culture.

At the height of the movement of determining the objectives of mathematics the list of objectives had become quite large. Schorling in 1925, having made a study of objectives, submitted a list of 520 statements which he termed objectives, elements or items. Other similar lists appeared, and some writers were becoming alarmed fearing that the movement had gone beyond the point of usefulness and

that the long lists were confusing the teachers and actually were detrimental. Surely it should not be implied that the teacher should attempt to go before his class to make daily contributions to 520 objectives, but the fact cannot be overlooked that much of the vague and aimless teaching is due to the fact that the objectives are not clear in the minds of teacher and pupils. The teacher who is thoroughly familiar with the objectives of his course will be in a position to select for each day's plans those to which a real contribution can and should be made.

Movement of Meaning and Understanding

Algebra and geometry in the early high school curriculum were filled with abstractions which the pupils failed to understand. They memorized definitions, rules and proofs which had little or no meaning to them. The teacher hoped that meanings would develop later as the pupils progressed in the course. Since the concepts of mathematics are the basis for all future work errors and difficulties increased as the pupils advanced, and the study of mathematics became more and more difficult. Progress was retarded.

Numerous investigations have disclosed that the major cause of typical errors and difficulties is lack of understanding. For example, when a pupil's response to $x^2 \cdot x^3$ is x^6 he evidently has not grasped the meaning of positive integral exponent, and if his answer to $x/a+y/a$ is $(x+y)/2a$ he has no conception of the meaning of a common fraction.

Some leaders in mathematics quite early recognized the need for developing understandings.

In 1912 E. H. Moore pointed to the fact that assurance in mathemathematics could not come from drill but must come from understandings, and that understanding of new ideas must come from previously acquired understandings. It was being more and more realized that "drilling pupils" and "teaching" are not the same and that understandings must come first; drill; if at all, may follow later, and that there was need for many changes in the methods of teaching.

Concrete Mathematics

The Committee of Fifteen in 1911 had suggested that concrete exercises and concrete relations of geometry would be helpful and that geometric illustrations should be used to clarify algebraic concepts and principles. T. P. Nunn of England was one of the first to make use of geometric diagrams in a textbook on algebra to clarify meanings of such algebraic processes as multiplying and factoring polynomials. The National Committee of 1923 declared that understanding of the number system should be an objective of high school

arithmetic. The report of the Progressive Education Committee in 1941 discusses at length the development of understandings of concepts in problem solving.

The influence of the movement for concrete mathematics on present day teaching is apparent in all modern textbooks and class work. Objects in the class room and out of doors are used to clarify such concepts as lines, angles and polygons. The number scale gives meaning to signed numbers and the processes with signed numbers. Squared paper makes concrete the process of extracting square root. Scales illustrate how to solve equations. Home made models help training in space imaginations. Theorems to be proved in geometry are established first by drawing, measuring on paper following. The slide rule is taught as a calculating instrument; the parallel ruler to draw parallel lines; and the micrometer and transit to measure dimensions and angles. To this should be added the motion picture, slides and filmstrips. So rapid was the increase in the use of concrete material that in 1945 the entire Eighteenth Yearbook of the National Council of Teachers of Mathematics was devoted to the discussion of Multi-Sensory Aids in the Teaching of Mathematics.

The problem of developing understandings in mathematics has led to a number of movements, each aiming to improve the prevailing teaching procedure. The predominant method of instruction fifty years ago consisted of the following steps: 1. The new process or principle was illustrated and explained by the teacher. Often the pupil was expected to obtain this explanation without the aid of the teacher by reading the textbook. 2. A typical exercise was worked out by the teacher to explain the use of the new principle in the new process to be learned. 3. Practice or drill followed to make responses rapid. 4. A lesson was assigned for home work. 5. The pupil recited in class. 6. A test was administered.

This procedure is commonly denoted as the "lesson hearing" method. It has been very popular because it is so easily administered. In fact, it is so simple that many administrators have claimed that "anybody could teach mathematics," especially algebra.

Applied Mathematics

It is not to be inferred that during the early period there were no teachers who used better methods. At all times outstanding personalities have made mathematics interesting and understandable. John Perry sought solution of the problem of improvement by bringing in the mathematics used in other school subjects, thereby starting a movement for applications of mathematics. Teachers supported it enthusiastically and discussed it widely throughout the country. Applications supply an excellent motive for study, vitalize

mathematics, clarify understandings and teach pupils how to use what has been taught. Applications were drawn not only from various school subjects but also from out of school life, from trades and shops. Several lists of practical problems were made available, and in 1943 the Seventeenth Yearbook of the National Council of Teachers of Mathematics compiled an extensive list of applications suitable to junior and senior high school courses. The movement has grown to include the mathematics that functions in every day life, i.e., the social applications. They "enrich" the work in mathematics. In present day mathematics applications play an important part in teaching. They have informational value; arouse interest; teach pupils how to use mathematics; clarify understandings and give meaning to the mathematical processes.

The Use of Projects

The project method is another attempt to improve the teaching procedure. It is based upon the theory that a considerable amount of mathematics may be taught by relating it to some project in which individuals or groups of pupils have become interested. When need for mathematics arises in the project certain topics are suggested for study. The projects may originate in other school subjects or may be suggested by interests of various pupils. Mathematics then enters incidentally. The project is used to motivate and arouse interest in the mathematics. The chances are good for a favorable attitude toward study. Some projects are of interest only to individual pupils, especially the superior pupils. They may work on them outside of school time in addition to the assignment made for the entire group. The Joint Commission offers as examples seven projects for superior pupils in algebra, and two for pupils in trigonometry. At the close of the second decade the project method had gained in popularity. The method, however, has failed frequently because it was attempted to teach an entire course by use of projects. In such cases mathematics is no longer presented as a science and the pupil acquires a distorted view of the subject. In present day teaching the value of projects is not overlooked. They deepen the pupil's insight, increase understandings, enrich the course and train in correct habits of work. A limited use of good projects can be made very effective.

The Laboratory Method

Dissatisfied with the prevailing teaching procedure Professor E. H. Moore reached the conclusion that a constructive program for mathematics requires the development of a laboratory system of instruction. During the first decade some schools began to experiment with that method. Some even established mathematical laboratories

patterned after the science laboratories and obtained excellent results. There is much to be said in favor of the method. The atmosphere is one of exploration rather than direction The pupil engages in the activities of observing, measuring, drawing, comparing, classifying and generalizing. He formulates definitions and principles in his own words before exact statements are given by the teacher or textbook. The meanings of concepts and principles so derived are understood so that he can use them intelligently in situations in which they occur. Not many laboratories, however, were actually established owing to the expense involved for supplies and equipment. Yet, in present day teaching the laboratory method is being used by teachers to a limited extent for certain types of work in the regular classrooms. The materials need not be expensive. Squared paper, ruled blackboard, protractors, compasses, and home made instruments are usually sufficient.

Sound arguments can be presented for each of the foregoing methods. The difficulty arises when one is being used exclusively. The resourceful teacher who has in mind definite objectives will know which method in a particular case is the most suitable for his purposes. He uses supervised study when he feels the need for training pupils in correct habits of study. To arouse interest in a topic which may have slight appeal to the pupils he may bring in a project to show the need for it and to arouse interest in it. To discover a new relationship, such as the angle relation of the angles of a triangle, he may use the laboratory method. A change of procedures will eliminate the danger of the work getting monotonous as is often the case when day after day the same procedure is followed. Each of the foregoing methods originated in the desire to improve the teaching of mathematics. They are still used to serve the same purpose in present day teaching.

Movement for Improved Teaching Process

During the past fifty years the teaching process has been subjected repeatedly to careful analyses by those who felt the need for improvement. There have always been adverse criticisms of the results of teaching, and teachers have profited by trying to eliminate criticisms. Since the days of "lesson hearing" as a way of teaching steady progress has been made. The teacher of today is master of many methods. At the end of the second decade H. C. Morrison reexamined the teaching process. He thought of teaching as a "practice" on the same level as the practice of law or the practice of medicine, and presented the results of his wide experience and study in his book *The Practice of Teaching in the Secondary School.* Successful teaching according to Morrison makes use of certain definite steps to overcome specific

difficulties encountered by pupils, such as the following. Chapters in a course vary greatly in difficulty. One chapter, so simple as to offer slight challenge to the pupils, may be followed by one so difficult as to discourage even the best. Clearly, different methods of teaching are required for the two chapters. An inventory test will disclose information as to the pupils' previous experiences to make teaching more intelligent. Furthermore the "relation" between two consecutive chapters may not be recognized by the pupils. Hardly have they become interested in the topic of one chapter when they find themselves working on another entirely unrelated to what has preceded. A "preview" of the new chapter should therefore be the first step in the teaching process. It bridges the gap between these consecutive chapters and retains the pupil's interest

It is well known that pupils waste much time doing the assigned home work because they fail to see the relation between the teacher's explanation in class and the particular problems they are to work out at home. To remove the difficulty Morrison suggests another important step in the teaching procedure. Immediately following the explanation a careful presentation should be made, step by step, of the procedure that has been used and which the pupils are to employ in the solution of the assigned problems. If possible, they should begin the home work in the class room under supervised study conditions.

Thus the lesson hearing teacher is gradually disappearing in present day teaching and the professional teacher is taking his place.

Summary

It has been attempted to review the more important movements for improvement of the teaching of mathematics during the past five decades and to show how they have affected present day teaching. Starting with a "lesson hearing" procedure steady progress has been made, and today teaching has attained the rank of a profession. No longer can it be said that "anybody" can teach mathematics.

When we are thinking about the movements which have brought about such far reaching changes let us not forget the men and women who had the vision and the courage to break away from tradition. They belonged to the generation of E. H. Moore, Herbert E. Slaught, David Eugene Smith, E. R. Hedrick, U. G. Mitchell and G. W. Myers. They were followed by a new generation which took over the task of putting their ideas into practice. They wrote books and articles and worked with committees and commissions. They spent their best years in rendering a service to the teaching profession. Many problems have been solved. Many more remain to be solved. That will be the task of the present generation as we pass into the second half of the century.

There will be an increasing demand for boys and girls with mathematical training. The importance of mathematics in education will be steadily on the increase. Teaching procedures will have to be improved still further. This generation of teachers fortunately is well trained and organized to solve new teaching problems when they arise because a sound foundation on which to build has been laid by the teachers of the first half of the century and their leaders.

THE DEVELOPMENT OF A COURSE IN PHYSICAL SCIENCE*

GLENN H. UPDIKE
Senior High School, Elkhart, Indiana

In 1942 when, due to the war emergency, courses in physics and chemistry were being stressed for defense training, it was suggested that at least 50% of our students be directed into those fields of study. A survey of the 1942 graduating class revealed that nearly 70% had been enrolled in either physics or chemistry. Several had taken both courses. Our problem was not how to increase the science enrollment, but instead was what to teach these people we now have.

It was assumed that any student intending to study further in the field of science, whether pure or applied, should take the traditional course in physics and chemistry. The remaining students were to pursue a modified physics or chemistry course with emphasis placed on the needs of the individual. This resulted in the offering of what were called "A" and "G" courses.

The average student in the "G" course was a boy who had taken general mathematics instead of the traditional algebra, geometry, and trigonometry, and was taking several industrial courses. Also there were some, both boys and girls, who were just wanting to get a diploma. Most of these people were finding jobs in factories or business immediately upon completion of high school.

It was to provide learning experience, in the physical science field, suited to the development and needs of this group that the course in Physical Science was developed. The educational development of the student could quite well be determined by examining his cumulative record.

The first question to answer was what subject matter to include in the course. After investigating the thinking of others working in the field of the physical sciences by surveying textbooks in physical science, and talking with physics and chemistry teachers, it seemed

* Read before the Physics Section of the C.A.S.M.T. at its "Golden Anniversary" Convention in Chicago, November 24, 1950.

proper to include in the course about 75% physics, 15% chemistry, and 10% earth science and astronomy.

There were three possible ways of organizing the subject matter. One, by topics such as may be found in a general science course. This would lead to an advanced general science course. A second plan would have consisted of studying physics for several weeks, then spend some time on chemistry and a similar period on geology or earth science. It was our wish to have a course in which we could study matter and energy in some logical manner. An outline of Physical Science that had been developed by Dr. Lark Horwitz of Purdue University was adapted to meet our needs for a one year course on the high school level.

The course is divided into twelve units.

I. Introduction
  A. The nature of Physical Science
    1. Discovery and invention
    2. Scientific development
    3. The scope of physical science
    4. Introduction of the concept of matter and energy
  B. Measurement
    1. Concept of measurement
    2. Measurement of length, weight, and time
    3. Units: English and metric system
  C. Accuracy and significant figures
    1. Rules of computation

II. Earth science
  A. The Universe
    1. The earth
    2. Our solar system
    3. Beyond the solar system
    4. Applications
  B. The earth's crust
    1. Earth's crust is changed
    2. Man's use of materials of the earth's crust
    3. Conservation of materials

III. Heat and its effects
  A. Introduction to the study of heat
    1. Heat, a form of energy
    2. Distinction between temperature and heat quantity
    3. Some effects of heat
  B. Temperature and the measurement of temperature
    1. Temperature
    2. Thermometers
    3. Thermal expansion of solids
    4. Thermal expansion of liquids
    5. Thermal expansion of gases
  C. Calorimetry and change of state
    1. Heat quantity
    2. Change of state
  D. Heat transfer
    1. Convection
    2. Conduction
    3. Radiation and absorption

- E. Weather and climate
  1. Factors influencing weather
  2. Weather forecasting
  3. Man's control of atmospheric conditions

IV. Basic principles of chemistry
- A. Chemical and physical changes
  1. Properties of matter
  2. Changes in matter
  3. Elements and compounds
  4. Pure substances and mixtures.
- B. Oxygen and combustion
  1. Preparation, properties and uses of oxygen
- C. Nature of chemical processes
  1. Atoms and molecules
  2. Atomic weight
  3. Molecular weight
  4. Valence and how to picture it

V. Force, energy, and machines
- A. Force
  1. Concept of force
  2. Concept of gravitation
  3. Combination of two or more forces acting at the same time
  4. Effect of a force in a given direction
  5. Equilibrium
- B. Force and Motion
  1. Uniform motion
  2. Non-uniform motion
  3. Newton's laws of motion
  4. Friction
  5. Circular motion
- C. Work, energy, and power
  1. Concept of mechanical work
  2. Energy, the capacity for doing work
  3. Law of conservation of energy
  4. Power
  5. Simple machines
- D. Transformation of energy
  1. Mechanical energy to heat energy
  2. Heat energy to mechanical energy

VI. Matter is made of molecules
- A. Kinetic theory of matter
  1. Development of ideas about nature of matter
  2. Molecular structure of matter
- B. Molecular forces and the properties of matter
  1. Molecular forces in solids
  2. Molecular forces in liquids
- C. Solutions, suspensions, emulsions, colloids, and gels
  1. Nature of a solution
  2. Suspensions

VII. Properties of fluids
- A. Fluids at rest
  1. Nature of a fluid
  2. Pressure exerted by a fluid
  3. Buoyancy
- B. Fluids in motion
  1. Characteristics
  2. Bernouilli's theorem applied to fluids
  3. Viscosity

VIII. Basic principles of electricity
- A. Electrons—at rest and in motion
  1. Introduction and history of electrostatics
  2. Principal concepts of electrostatics
  3. Electrical resistance, Ohm's law
  4. Heat produced by flow of current
- B. Electric current and magnetism
  1. Nature of magnetism
  2. Magnetic effect of a current
  3. Force on a current carrying wire in a magnetic field
  4. Electro magnetic induction

IX. Chemistry and electricity
- A. Electric currents through liquids
  1. Ions and ionization
  2. Electrolysis of water
  3. Electroplating
  4. Electrolytic extraction of elements
  5. Laws of electrolysis
  6. Electric cells
- B. Atoms are made of electricity
  1. Chemical similarities among the elements
  2. Electron groups and chemical properties
  3. Types of chemical change

X. Chemical substances and their compounds
- A. Non-metals and their compounds
- B. Some useful metals

XI. Wave motion
- A. Concept of wave motion
  1. Definitions
  2. Types of waves
  3. Properties of wave transmission
- B. Sound waves
  1. Sound as a form of energy
  2. Reflection of sound
  3. Fundamental properties of sound
  4. Doppler's principle
  5. Interference
  6. Vibration of strings
  7. Organ pipes
  8. Musical instruments
- C. Light waves
  1. The nature of light
  2. Sources of light
  3. Shadows
  4. Color
  5. Photometry
- D. Reflection and refraction of light
  1. Reflection
  2. Refraction
  3. Lenses
  4. Optical instruments

XII. Electronics
- A. Conduction of electricity through gases
  1. Basis for conductivity of gases
  2. Discharge through gases
  3. The X-ray tube
- B. Emission of electrons from solids
  1. Photoelectric emissions
  2. Thermionic emissions

The next step was to provide learning experiences for the students. this means the selection of reference material, laboratory exercises, films, demonstrations, and the preparation of a study guide for the student.

A search for textbooks written on the high school level soon convinced us that few were available. Since we found none that suited our needs completely, it seemed wise to use multiple reference books instead of one textbook. The books selected were:

Modern Life Science, by Carlton and Williams
The Physical Sciences, by Eby and others
Our Physical World, by Eckels and others
Living Chemistry, by Ahrens and others
Chemistry and Human Affairs, by Price and Bruce
Physics, A Basic Science, by Burns and others
Experiences in Physics, by Willard
Science for Everyday Use, by Smith and Vance

In addition to these there were placed in the library several books in related fields.

In order to help the student in his study the outline was broken down into a series of study problems for each unit. A typical problem follows.

UNIT V. FORCE, ENERGY AND MACHINES

PROBLEM 1.

Everyone is familiar with the effects of forces even though the forces themselves can not be seen. We recognize the forces of the wind, moving water, a weight dropped on a foot, in a moving automobile, and others only from the effects produced. A house is pushed over by a tornado, the locomotive pulls a train up a long grade, a sailboat is pushed by the wind, the dentist pulls a tooth, and many other examples indicate that force is a push or a pull.

A. Force
   1. Concept of force
      a. The way a body moves or stays at rest is the result of force
      b. Forces may be gravitational, mechanical, electrical, magnetic, etc.
      c. Forces are commonly measured in weight units
      d. Force has direction and magnitude
      e. Forces may be represented by scale drawings
   2. Concept of gravitation
      a. Gravity, a universal property of matter
   3. Combination of two or more forces acting at the same time
      a. Meaning of resultant
      b. Resultant of forces acting at an angle of 0°
      c. Resultant of forces acting at an angle of 180°
      d. Resultant of forces acting at an angle of 90°
      e. Resultant of forces acting at any angle
   4. Effect of a force in a given direction
      a. A force is effective in directions other than that in which it is applied
      b. Graphic solution for components of force
   5. Equilibrium
      a. Forces acting at a point
         (1) Equilibrant
      b. Parallel forces not at a point

(1) Moment of force
(2) Sum of moments zero when in equilibrium

c. Conditions of equilibrium
d. Center of gravity
(1) Concept of center of gravity
(2) Properties of center of gravity
(a) Object behaves as if weight were concentrated at the center of gravity
(b) Center of gravity need not be within the material
e. Stability
(1)
(2)
(3)

Study suggestions:

1. Attach a spring balance to a block of wood, of known weight, placed on a table. Determine the force necessary to move the block when the direction of pull is parallel with the table top.
Make a scale drawing to show the direction and amount of two forces acting on the block. Represent the block as a point and the forces as lines drawn in the proper direction
2. Since gravity is a universal property of matter, why don't two dishes move together when placed upon the table?
3. Attach two spring balances to the block of wood of known weight, one near each end. Observe the force necessary to lift the block when:
a. the pulls are vertical
b. the pulls make an angle of about 30° with the vertical
c. the pulls make an angle of about 45° with the vertical
d. the pulls make an angle of about 60° with the vertical
4. To show the resolution of forces into components, attach the spring balance to the heavy block of wood
Determine the force necessary to move the block when:
a. the pull is horizontal
b. the pull is at an angle of about 30° with the table
c. the pull is at an angle of about 45° with the table
d. the pull is at an angle of about 60° with the table
e. the pull is at an angle of 90° with the table
5. Find the weight of an irregular stick by using only a knife edge and one known weight
6. What is meant by the center of gravity?
7. Explain stability in terms of center of gravity
8. Under what conditions is a body said to be in equilibrium?

Solve:

1. Find the resultant of a force of 40 lb. and a force of 80 lb. when both are acting in a northward direction from the same point
2. What is the resultant force when one force of 60 lb. acts westward, a second force of 120 lb. acts westward, and a third force of 30 lb. acts westward?
3. What single forces will replace a force of 10 lb. acting south and a 40 lb. force acting east?
4. A boy weighing 150 lb. sits in a hammock. What is the pull at each end of the hammock if the ropes make an angle of 45° with the horizontal?
5. A 50 lb. boy hangs from the center of a 60 ft. clothesline. His weight causes the line to sag two feet. Find the tension on the line

Laboratory:

A. To find the resultant of two or more forces acting at a point
Materials: Spring balances, string, ruler, compass, weights
Things to do: Suspend two spring balances from supports at the blackboard.

Attach the ends of a string to the hooks of the balances. Hang a weight on the string. On a sheet of plain paper indicate the direction and amount of each force. Consider the balances as the forces acting at a point and the weight as the equilibrant. Find the resultant making a scale drawing. How does this resultant compare with the equilibrant?

B. To study moments of force

Materials: Meter stick, support, weights

Things to do: Balance the meter stick on the support. Hang two weights on the meter stick at such places as will balance it. Repeat using weights at different places. Can you place two weights so that the stick is not balanced and determine where to place a third weight to balance the stick without trial and error methods? Record all data. Observe that you are studying moments of force

Trial	Center of Gravity	Position of Weights				Clock-wise Moment	Counter clock-wise Moment	Error
		Gm.	Gm.	Gm.	Gm.			
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								

It should be noted that in addition to the more or less formal laboratory exercises in the course, there are many study questions that may be answered by the use of simple equipment. This makes the assignments what we like to call laboratory study problems.

It is hoped that this course in Physical Science will result in the student having a knowledge of some basic principles of science and that because of this knowledge will be able to explain everyday happenings. In taking this course a student may begin study on his own level and go as far as he desires. There is plenty of work to do in the field of science. Thus another opportunity is offered for a student to be self-directed.

Carburetor preheater, for quick-starting of automobile engines in cold weather, is a unit installed between carburetor and intake manifold. The unit contains a wire heated electrically from the battery. When gasoline hits the hot element it is instantly vaporized.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

Report of the Chicago Meeting

The meeting of the Board of Directors of the Central Association of Science and Mathematics Teachers was held in the American Room of the Edgewater Beach Hotel, Chicago, Illinois, on November 23, 1950.

The meeting was called to order by President Allen F. Meyer at 7:30 P.M. The following officers and Board of Directors were present:

Allen F. Meyer	Ralph W. Lefler	Martha E. Curtis
Mary A. Potter	Donald W. Lentz	Philip Peak
Cecilia J. Lauby	H. Vernon Price	John A. Habat
Edwin W. Schreiber	A. C. Brookley	Edgar S. Leach
Ray C. Soliday	Charlotte Grant	Milton Pella

Since this was the Golden Anniversary of the Central Association of Science and Mathematics Teachers, an invitation was extended to former members of the Board of Directors to attend this meeting. These former Directors together with others who were invited to attend this meeting included the following:

Ray Agren	Jerome Isenbarger	J. S. Richardson
A. O. Baker	J. T. Johnson	Philip Tapley
Walter Carnahan	Fred Leonhard	W. R. Teeters
Joseph Dickman	Ella Marth	Bjarne Ullsvik
Franklin Frey	John C. Mayfield	Joseph Urbancek
Walter Gingery	Harold Metcalf	Kenneth Vordenberg
Glen Hewitt	Milton Oestreicher	Glen W. Warner
Katherine Isenbarger	George Peterson	Marie Wilcox
	John Potzger	

Following the roll call of officers and directors, President Meyer welcomed the guests and extended greetings to all on this the fiftieth anniversary of the founding of the Central Association of Science and Mathematics Teachers. Compliments were extended to Mr. Schreiber because he was able to contact so many of the former members of the Board of Directors and secure their attendance at this meeting.

Mr. Soliday moved, Dr. Grant seconded the motion that the minutes of the May meeting of the Board of Directors be approved as written. Mr. Urbancek requested that the "h" be deleted from the spelling of his name as written in the minutes. Mr. Brookley moved. Mr. Peak seconded the motion and it was passed that the minutes be approved as written and corrected.

President Meyer called attention to the highlights of the Fiftieth Anniversary Convention. He expressed his sincere appreciation to all of those who had worked so long and diligently to make this Convention a success.

Mr. Edgar Leach, Coordinator of Local Arrangements Committees submitted a duplicated report. He called the attention of the Board of Directors to the untiring work of the local committees and expressed his sincere appreciation for all of their work and cooperation. The question of recognition of student operators of equipment and student exhibitors was discussed.

Mr. Donald Lentz moved, Miss Potter seconded the motion and it was passed that Mr. Leach's report on local arrangements be accepted. Miss Potter moved, Dr. Grant seconded the motion that Mr. Leach be enthusiastically thanked for untiring work and that the Board extend to him its deep and sincere appreciation for his splendid work in behalf of the Central Association of Science and Mathematics Teachers. The motion carried unanimously.

Mr. Edwin W. Schreiber, Historian, submitted his report. He recalled that since the establishment of the office of Historian in 1943 he had enjoyed serving in this capacity. He is working on a complete roster of the officers and directors of CASMT during the past fifty years and this is almost completed. He suggested

that on the completion of the roster he recommends that it be published in the Journal, SCHOOL SCIENCE AND MATHEMATICS.

Mr. Lefler moved, Mr. Brookley seconded the motion that the roster be referred to the editor of the Journal for publication. The motion carried.

Mr. Brookley moved, Mr. Price seconded the motion and it was passed that the Historian's report be accepted with commendation.

Mr. Fred Leonhard, chairman of the Membership Committee submitted a duplicated report. The total membership of CASMT as of November 22, 1950 is 1087. This membership is spread over the various fields of interest in the following percentages which are based on the preferences as stated by the individual members at registration.

(Note: Some individuals express an interest in more than one field)

Mathematics	57.3%	Biology	19.4%
Physics	34.3%	Elementary Math.	9.2%
Chemistry	27.8%	Elementary Science	9.2%
General Science	20.9%	Geography	4.0%

Mr. Price moved, Mr. Leach seconded the motion that Mr. Leonhard's report be accepted with thanks and appreciation. The motion carried.

Mr. Walter Carnahan, Editor-in-chief of the Anniversary Publication submitted his report in printed form—The Anniversary Publication, *A Half Century of Science and Mathematics Teaching.*

Mr. Brookley moved, Mr. Pella seconded the motion that the Board of Directors and the officers accept the report of the Editor-in-chief, Mr. Walter Carnahan, and that the deepest appreciation and sincerest thanks be extended to Mr. Carnahan and his editorial committee for the completion of a work that is an outstanding achievement, a work which will stand as a lasting monument, a tribute to the Central Association of Science and Mathematics Teachers. The motion carried unanimously. A rising vote of thanks and appreciation was given to Mr. Carnahan.

Dr. John Potzger, chairman of the Publicity and Promotion Committee for the Anniversary Publication, gave the report for his committee. Each issue of the Journal throughout the past year has carried some information concerning the Anniversary Publication. Dr. Potzger extended thanks and appreciation to the Printing Shop of the George Washington High School, Indianapolis, Indiana which was of great assistance to his committee by printing publicity materials. Dr. Potzger and his committee recommended that copies of the Anniversary Publication be sent to specifically named individuals and institutions. Dr. Potzger also urged those present to recommend that the libraries in the schools and colleges which they represent, purchase a copy of *A Half Century of Science and Mathematics Teaching.*

Mr. Peak moved, Mr. Price seconded the motion that Dr. Potzger's report be accepted. The motion carried.

Dr. Grant moved, Dr. Pella seconded the motion that the sincere thanks and appreciation of the officers and Board of Directors be extended to Dr. Potzger and his committee for their splendid work. The motion carried unanimously.

Mr. Walter Gingery, chairman of the Journal Committee, reported that the details of this committee's report were contained in the report of the Editor of the Journal and the Business Manager and that he would let these reports speak for his committee.

Mr. Peak moved, Mr. Leach seconded the motion and it was passed that the report of Mr. Gingery be accepted.

Dr. Warner, editor of the Journal, stated that he would prefer to make a report at the Saturday afternoon meeting of the Board of Directors.

Dr. Pella moved, Mr. Peak seconded the motion that Dr. Warner's report be postponed. The motion carried.

Mr. Ray Agren, editor of the *Yearbook*, reported that the *Yearbook* would net

CASMT a profit of approximately one hundred dollars. This year some former advertisers failed to purchase advertising space, but some new advertisers were secured. Mr. Agren recommended that advertising rates be increased to offset the increased printing and publishing costs. The possibility of deleting such pages as the "Reservation Page" from the *Yearbook* was discussed.

Mr. Brookley moved, Dr. Price seconded the motion that the report of the editor of the *Yearbook* be accepted with thanks. The motion carried.

The Treasurer and Business Manager, Mr. Ray Soliday, submitted a duplicated report of the financial status of the Association. He called attention to the fact that we probably spent more at this Convention than at any other, but that was understandable in view of this being the fiftieth anniversary convention. Mr. Soliday called attention to the fact that printing costs have increased about 13%. About $2,500.00 was spent on the Anniversary Publication.

A discussion followed as to what disposal should be made of the type of the Anniversary Publication. Rental rates on the type are rather high.

Dr. Price moved that the Board of Directors give the Business Manager and the Publicity and Promotion Committee of the Anniversary Publication the authority to dispose of the type as they saw fit. Mr. Lefler seconded the motion. The motion carried.

Mr. Price moved, Mr. Leach seconded the motion, and it was passed that the report of the Treasurer and the Business Manager be accepted.

Mrs. Marie S. Wilcox, chairman of the Policy and Resolutions Committee, submitted a duplicated report.

Mr. Peak moved, Dr. Pella seconded the motion and it was passed that Mrs. Wilcox's report be accepted.

Mr. Kenneth Vordenberg, coordinator of the Policy and Resolution Committee Projects, reported that two of the chairmen of projects would make reports at the General Meeting on Saturday. Mr. Vordenberg also stated that he would prefer to make an additional report at the Saturday afternoon meeting of the Board.

Dr. Grant moved, Mr. Price seconded the motion and it was passed that Mr. Vordenberg's report be accepted and that he make an additional report at the Saturday meeting.

Mr. Donald Lentz, representative of CASMT on the AAAS Cooperative Committee, submitted a duplicated report. Mr. Lentz also reported that the Cooperative Committee had made notable strides in securing the U. S. Office of Education to cooperate with them in their activities.

Mr. Peak moved, Dr. Martha Curtis seconded the motion that Mr. Lentz's report be accepted. The motion carried.

Matters concerning communications which have been received by President Meyer were delayed, by common consent, until the Saturday meeting. Miss Potter moved and Mr. Price seconded the motion that the chairman of the Student Exhibit Committee invite the student exhibitors to the General Meeting on Friday morning to be introduced. The motion carried.

Mr. Brookley moved, Dr. Curtis seconded the motion that the expenses of the local arrangements committee be handled as in the past. The motion carried.

The meeting adjourned at 11:15 P.M.

Saturday Morning Business Meeting

President Meyer called the meeting to order at 8:40 A.M. Saturday, November 25, 1950, in the Ball Room of the Edgewater Beach Hotel.

Mr. Warner moved, Mr. Brookley seconded the motion that the minutes of the 1949 meeting as printed in the Journal be approved. The motion carried.

Mr. Fred Leonhard, chairman of the Membership Committee, reported that 450 individuals had registered at the Convention. This number included guests as well as members. The total membership in CASMT as of Friday, November 24, 1950 was 1,111. The question of attendance at meetings of individuals who were neither members nor guests was discussed. This raises the procedure of the

best method of handling attendance at the meetings.

Dr. Warner, editor of the Journal, reported that two members of CASMT have died since our last meeting. These two were: Professor Raleigh Schorling of the University of Michigan and Mr. Frank B. Wade of Indianapolis who was president of CASMT in 1923. A minute of silence was observed in silent tribute to these deceased members.

Dr. John Potzger, chairman of the Publicity and Promotion Committee of the Anniversary Publication, reported that copies of *A Half Century of Science and Mathematics Teaching*, the Anniversary Publication, were available at the stand opposite the registration desk. He urged the sale and promotion of this book. Again he called attention to the publicity which had appeared in the Journal and he urged the members to send copies to their friends as Christmas gifts.

Mr. Vordenberg moved, Mr. Warner seconded the motion that Dr. Potzger's report be accepted. The motion carried.

Mr. Walter N. Smith, chairman of the Place of Meeting Committee, reported that Cleveland, Ohio has been selected by the committee as the place to hold the 1951 Convention.

Mr. Franklin Frey moved, Mr. Brookley seconded the motion that the report of the Place of Meeting Committee be accepted. The motion carried.

The Secretary, Dr. Lauby, reported that Miss Helen Trowbridge had requested that her resignation from the Board of Directors and chairmanship of the Project Committee be submitted. The resignation is requested because of ill health.

Dr. Potzger moved, Mr. Soliday seconded the motion that the resignation be accepted. The motion carried.

Mr. Frey moved, and Mr. Read seconded the motion that the Secretary express the appreciation of the members of CASMT to Miss Trowbridge for her help and service and extend to her all best wishes for a speedy recovery. The motion carried.

Dr. Harold Metcalf, chairman of the Nominating Committee, submitted the following slate of officers:

President: Donald W. Lentz, Ridge Road School, Parma, Ohio

Vice President: Philip Peak, Indiana University, Bloomington, Indiana

As a Director for two years to replace Philip Peak, Miss Mamie Anderzhon, Oak Park Elementary School, Oak Park, Illinois.

As a Director for two years to replace Miss Helen Trowbridge, Mr. John R. Mayor, University of Wisconsin, Madison, Wisconsin.

As Directors for three years, terms to expire in 1953:

H. Vernon Price, University High School, Iowa City, Iowa
Harold Haggard, Schurz High School, Chicago, Ill.
Cecilia J. Lauby, Illinois State Normal University, Normal, Ill.
Fred Leonhard, Redford High School, Detroit, Mich.

Dr. Metcalf moved, Mr. Carnahan seconded the motion that this group of persons be unanimously elected. The motion carried.

Mr. Donald Lentz, the newly elected president, expressed his sincere appreciation in the trust which the members had placed in him by electing him to the office of president. He pledged to do his utmost to make CASMT as outstanding in its second half century as it had been in its first. He acknowledged that such an achievement could not be accomplished alone, but needed the full cooperation and efforts of all members of the Association. Mr. Lentz asked the members to give him their support, cooperation, suggestions, and encouragement. As for himself, he pledged to do the very best that he was capable of doing.

Mr. Leach moved, Dr. Pella seconded the motion that the report of the Nominating Committee be accepted. The motion carried.

Mr. A. O. Baker, chairman of the Committee on the Revision of the By-Laws submitted a written report on Suggested Revisions. These Revisions had been published in the Journal as required by the constitution.

Dr. Metcalf moved, Mr. Soliday seconded the motion that the Revisions of the By-Laws as written in the duplicated report and as printed in the Journal be accepted. The motion carried.

Mr. Brookley moved, Mr. Soliday seconded the motion that the report of the Committee on the Revision of the By-Laws be accepted with gratitude and that this committee be discharged from further responsibilities. The motion carried.

Mr. Donald Lentz who is the representative from CASMT to the AAAS Cooperative Committees reported on the recent activities of the Cooperative Committees:

1. An effort was being made to coordinate the activities of the Cooperative Committees with the U. S. Office of Education.
2. Problems which the Cooperative Committees were considered included:
   a. Teacher certification and promotion
   b. Science curriculum in schools—college preparatory and general education.
   c. Laboratory equipment and procedure.
3. Visual Aids
   a. Usable classroom films
   b. Recommendations to produce films through commercial agencies.
4. Attitudes and viewpoints of the classroom teachers.

Mr. Mayor moved, Dr. Potzger seconded the motion that Mr. Lentz's report on the Cooperative Committees be accepted. The motion carried.

Dr. Potzger moved, Mr. Vordenberg seconded the motion that the greetings of the Association be sent to Dr. Paul Trump. His presence was missed, but all of the members are sending him the best of wishes for a speedy recovery.

The meeting adjourned at 9:35 A.M.

The Saturday Afternoon Meeting of the Board

The meeting of the officers and the Board of Directors was called to order by retiring president, Mr. Allen F. Meyer, in the American Room of the Edgewater Beach Hotel, Saturday, November 25, 1950 at 2:00 P.M. The following were in attendance:

Allen F. Meyer	Philip Peak	Martha E. Curtis	Harold Haggard
Mary A. Potter	H. Vernon Price	Milton Pella	Walter Gingery
Cecilia J. Lauby	Ralph Lefler	Edgar S. Leach	Marie Wilcox
Ray C. Soliday	A. C. Brookley	John Habat	Charlotte Grant
Donald W. Lentz	Glen Warner	J. R. Mayor	Fred Leonhard

Mr. Ray C. Soliday, Treasurer and Business Manager reported that eleven copies of the Anniversary publication had been sold at the Convention.

Dr. Glen Warner, Editor of the Journal, reported that the Journal was in need of an editor for the high school chemistry section. He asked that those present make suggestions for someone to fill this vacancy.

Mr. Walter Gingery, chairman of the Journal Committee, suggested that it seemed advisable that the Journal Committee meet at times other than at the Convention. This would give the committee better opportunity to study the needs of the Journal and to offer help and constructive suggestions. Mr. Gingery also recommended that some type of fireproof storage be provided for the Journal materials. These materials are irreplaceable and need protection.

It was suggested that the Journal Committee study the specific needs of the Journal relative to providing fireproof storage and make specific recommendations to the Board of Directors at the May meeting.

Mrs. Marie Wilcox reviewed some of the recommendations made by the Policy and Resolutions Committee at the Thursday meeting. These recommendations included:

1. Changes in the constitution

2. Activities of Project Committees
3. Selection of paid officers
4. Publications other than the Journal
5. Scheduling of section and general meetings at the Annual Convention
6. Formation of new committees such as Public Relations or Publicity Committees.

Mr. Brookley moved and Mr. Peak seconded the motion that we accept the recommendation of Miss Helen Trowbridge that the Project committee of which she was chairman be disbanded. The motion carried.

The resignation of Cecilia J. Lauby as Secretary of the Central Association of Science and Mathematics Teachers was discussed. A committee of the Board consisting of Mr. A. C. Brookley, chairman, Mr. H. V. Price, and Mr. Milton Pella had been appointed to make suggestions to the Board relative to filling the Secretaryship. The committee recommended that Mr. Wm. Herbert Edwards, Munford High School, Detroit, Michigan be asked to be Secretary.

Mr. Peak moved, Mr. Lefler seconded the motion that the report of Mr. Brookley's special committee of the Board be accepted. The motion carried.

Mr. Allen F. Meyer, the retiring president expressed his sincere thanks and appreciation for the splendid help and assistance which he had received during his term of office. Mr. Meyer gave great praise to the high spirit of loyalty and cooperation which is found among the officers, Board of Directors, and the entire membership of the Central Association of Science and Mathematics Teachers. Mr. Meyer turned the meeting over to the newly elected president, Mr. Donald Lentz.

President Lentz asked for the cooperation of all during the next year and stated that he would welcome suggestions.

Mr. Leonhard moved, Mr. Peak seconded the motion that the following officers be elected by the Board to serve for a period of three years, terms to expire in 1953:

Business Manager and Treasurer, Ray C. Soliday, Oak Park, Illinois.

Editor of the Journal, SCHOOL SCIENCE AND MATHEMATICS, Glen W. Warner, Lakeville, Indiana.

Historian, Edwin Schreiber, State Teachers College, Macomb, Illinois.

The motion carried.

President Lentz called attention to the Revision of the By-Laws which provided that the Executive Committee of the Board would consist of the President, the Vice President and the immediate Past President, therefore the Executive Committee would consist of Donald Lentz, Philip Peak, and Allen Meyer.

Dr. Lauby moved, Mr. Peak seconded the motion that the President appoint a committee to study the problems of Student Exhibits and to make specific recommendations to the Board at the May meeting. The motion carried.

Mr. Leach moved, Mr. Brookley seconded the motion that Mr. Donald Lentz continue to represent CASMT at the AAAS Cooperative Committee meetings. The motion carried.

Mr. Leach moved and Mr. Peak seconded the motion that the River Forest State Bank be continued as repository for CASMT funds. The motion carried.

Mr. Brookley moved that the Vice President act as Parliamentarian. Dr. Price seconded the motion. The motion carried.

A discussion of the status of the Geography section followed. Mr. Peak moved, Mr. Leonhard seconded the motion that the Geography section be continued for another year. The motion carried.

Miss Lauby moved, Mr. Price seconded the motion that the Board give Mr. Fred Leonhard a sincere vote of thanks and appreciation for the splendid work which he has carried on for CASMT as chairman of the Membership Committee. The motion carried.

The meeting adjourned at 3:50 P.M.

Respectfully submitted,
CECILIA J. LAUBY, *Secretary*

The Chemistry Section

The chemistry section met Friday morning, November 24, at 10:40 in the Lincoln Room, Edgewater Beach Hotel. Seventy members were present. The chairman, Mr. Clyde Dewalt of Glenbard Township High School, Glen Ellyn, Illinois, appointed the nominating committee and made other preliminary announcements.

The first talk was given by Dr. Eldrow Reeve of the Agricultural Research Department, Campbell Soup Company, West Chicago, Illinois. His subject was "Chemistry as Applied to Soil and Crop Production." The talk was illustrated with appropriate slides. The characteristics of a desirable soil were emphasized. The state of subdivision of soil particles, chemical elements present, and chemical and biochemical reactions within the soil were all fully discussed. The chemical elements were divided into three groups:

(a) Major plant nutrients including the elements nitrogen, phosphorous, and potassium
(b) Secondary plant nutrients including calcium, magnesium, and sulfur
(c) Trace elements including iron, manganese, copper, zinc, and boron.

The acidity of the soil as measured in terms of pH is an important factor. Most elements are more available for plant use at a pH of 6.5 or higher. Iron is an exception in that it is more available at lower pH values. The use of limestone as a soil conditioner in order to increase the pH of the soil was discussed. The amount of limestone needed depends not only on the pH of the soil, but also on its exchange capacity. Sands require less limestone while silt loams need more. The final slides showed various tomato vines that had been grown under varying soil conditions. A good phosphorus content and a pH of 6.5 or higher along with certain other nutrients seemed to give excellent tomatoes.

The second talk was given by Dr. Frank H. Reed, State Geological Survey Division, Urbana, Illinois on the subject; "Synthetic Liquid Fuels." His opening statements dealt with the early history of petroleum. He next emphasized that our annual needs of petroleum and its products require around two billion barrels (42 gallons each) of crude oil. He put the present national reserve at approximately 28 billion barrels. Dr. Reed felt that the ever present threat of a third world war had made necessary the further development of a synthetic fuels program by our national government. Wars make an increased demand on our petroleum reserves. It was during the second world war, in 1944, that the first Synthetic Fuels Act was passed. The Bureau of Mines was thus enabled to put 200 scientists to work on a thirty million dollar program of research in the production of liquid fuels from coal, natural gas, and oil shale. Since then, other legislative acts have made available more funds for further developments along these lines. Dr. Reed discussed the direct hydrogenation of coal as performed by the Bergues process. This method was much used by the Germans in the second World War. He also discussed the newer Fischer-Tropsch process which is an excellent method of converting natural gas into gasoline and other products. Many chemical by-products are obtained from this latter process. They include aldehydes, ketones, alcohols, and acids.

The following officers were elected for the year 1951:

Chairman—Gerald Osborn, Western Michigan College, Kalamazoo, Mich.
Vice-Chairman—Sylvan Michelson, University School, Columbus, Ohio
Secretary—T. A. Nelson, Lyons Township High School, LaGrange, Ill.

Gerald Osborn, *Vice-Chairman*

The Mathematics Section

The meeting was called to order at 10:45 A.M. by the Chairman, Dr. E. H.C. Hildebrandt, Northwestern University, Evanston, Illinois.

Dr. Hildebrandt introduced the other officers of the section: Vice-Chairman Enoch D. Burton, Shortridge High School, Indianapolis, Indiana, and Secretary Virginia Terhune, Proviso Twp. High School, Maywood, Illinois.

It was agreed to dispense with the reading of the minutes of the previous meeting, since they had been published in the journal.

The chairman announced the appointment of the nominating committee for the section: Miss Bernice Von Horn, Fenger High School, Chicago, Illinois, Miss Vivian B. Ely, George Washington High School, Indianapolis, Indiana, and Mr. Franklin Frey, Cass Technical High School, Detroit, Michigan. The committee later presented their recommendations for section officers for 1951 as follows:

Chairman—Mr. Enoch D. Burton, Indianapolis, Ind.
Vice-Chairman—Dr. H. Glen Ayre, Western State Teachers College, Macomb, Ill.
Secretary—Miss Geraldine Dolan, Cass Technical High School, Detroit, Mich.

The first speaker on the program was Dr. E. R. Breslich, Professor Emeritus, School of Education, University of Chicago, Chicago, Illinois. His topic was "How Movements for Improvement Have Affected Present-Day Mathematics Instruction." Among the movements developing from the beginning of the century to the present time was (1) the correlation movement, which has attempted to break down the water tight compartments of algebra, geometry, and trigonometry. Present day courses retain their traditional names, but each is used to clarify the work of the other wherever possible. (2) The general mathematics movement has brought the opportunity to enrich the course with applications and has bridged the gap between elementary and high school mathematics. It has also provided a terminal course in junior college for those not interested in continuing the study of mathematics. The movements (3) for setting up objectives in the teaching of mathematics, (4) for supervised study, (5) for developing understandings, (6) for stressing social applications, (7) for the project method, and (8) for the laboratory method were all shown by Dr. Breslich to have brought definite improvement in the teaching of mathematics. He pointed out that the difficulty arises when any one of the foregoing methods is used exclusively. The teacher of today is the master of many methods; the "lesson hearing" teacher is gradually disappearing and the professional teacher is taking his place.

Mr. Philip Peak, Indiana University High School, Bloomington, Indiana, spoke next on "What Contributions to Mathematics Instruction Can We Expect in the Last Half of the Twentieth Century?" With the belief that mathematics is not static, that ideas are extending and new ideas are developing, he indicated that many topics once thought important should now be stored away. The basic principles of algebra, geometry, and arithmetic will appear in the same text, all working together. Meaningful arithmetic and practice with it will continue to be stressed. Teachers will be better prepared and will continue to grow through workshops, conventions, and through other media for in-service training. They will themselves understand more than in the past the basic structure of our number system. The laboratory system will grow, mathematics courses will all be terminal and will give the student a complete unit each year. Teachers will be better trained to handle the general mathematics courses needed. A new kind of evaluation will develop—evaluation of critical judgment, analysis, choice of approach, interpretation of results, rather than just evaluation of computing. The teacher will drawn more from the community for materials and will give greater stress to the cultural phase of mathematics.

Approximately one hundred thirty teachers were present to hear these two very interesting and able speakers. The meeting was adjourned at 12:40.

VIRGINIA TERHUNE, *Secretary*

THE PHYSICS SECTION

The Physics Section met in the Michigan room of the Edgewater Beach Hotel with J. S. Richardson, chairman of the section, in charge.

Mr. Roger K. Harper and an assistant of the Illinois Bell Telephone Company gave a very interesting and instructive talk and demonstration entitled "Words

over Waves." It concerned the various types of telephone service available and the kind of wave used by each. He demonstrated and explained in a very striking manner the ordinary telephone, ship to shore phone, oversea phone, mobile telephones and the microwave transmission methods.

Mr. Richardson then introduced the officers of the section and heard the report of the nomination committee. The following officers were nominated and elected for the coming year:

Chairman—Mrs. Delia Redman, High School, New Haven, Ind.
Vice Chairman—Mr. S. Fred Calhoun, High School, Geneseo, Ill.
Secretary—Mr. Kenneth Vordenberg, Withrow High School, Cincinnati, Ohio

Mr. Glenn H. Updike told of the Physical Science course that had been developed and introduced into the Elkhart Indiana High School. He told of the problems involved and content of the course.

Mr. Robert Carleton, Esecutive Secretary of the National Science Teachers Association, spoke on the place of Physical Science in the High School curriculum. A period of general discussion then followed with many of those present joining in.

S. FRED CALHOUN, *Secretary*

THE ELEMENTARY MATHEMATICS SECTION

The Elementary Mathematics Section met in the Ball Room of the Edgewater Beach Hotel on November 24th. The meeting was called to order at 2:40 P.M. by Chairman John R. Mayor of the University of Wisconsin. Dr. Mayor introduced the Secretary, Ella Marth. Mrs. Lucile Gates, Vice-Chairman, was not able to attend. About fifty member were present.

The first speaker was Miss Alice Rose Carr of Ball State Teachers College, Muncie, Indiana. Miss Carr spoke on the "Development of Concepts Through Emphasis on Generalizations in Arithmetic." The speaker emphasized the necessity of every teacher being aware of the need for and the possibilities of generalizations at all levels. She pointed out that a concept is built up by presenting the idea and then reinforcing it and extending it at each successive level with appropriate applications. To illustrate, the speaker indicated that in beginning number work the idea of adding *like* quantities is taught. This idea is extended to computation with tens in the next grade. Later the same concept is used in adding fractions and again in computing with decimals. In algebra the pupils learn to manipulate further with *like* quantities in dealing with equations.

Miss Carr also stated how necessary it is for the teacher to clearly understand the generalizations. She must have the total picture of the development of arithmetic concepts to achieve the desired continuity. Appropriate procedures are also needed in this development.

The second speaker, Mr. E. H. Hamilton of Iowa State Teachers College, discussed how "Field Work Modifies Our Program in Arithmetic." Field work, which is done by the regular staff members of the teachers college under state coordinators, consists of visiting schools, conferring with teachers and supervisors, and serving as resource people for county workshops. The major activity is demonstration teaching.

In his field work the speaker said he found too many instances in which the pupils are subjected to authoritarian teaching; that they are not stimulated to ask questions; and that they are unaccustomed to handling materials in classes. Mr. Hamilton indicated that in the children's minds a "great chasm" exists between the symbol and physical reality which it represents. The reasons suggested for this condition are that teachers are teaching as they were taught and are afraid to allow pupils to ask questions. Furthermore teachers are not aware of the wide range of individual differences which exist in classes.

To improve the teaching of arithmetic Mr. Hamilton made the following recommendations. The teacher training course should give emphasis on the "how

and why" of arithmetic processes. A collection of teaching aids should be made by student teachers for use in classes. The necessity of grouping children according to ability and achievement should be clearly demonstrated. Student teachers should be clearly demonstrated. Student teachers should also be made aware of the relation of behavior problems to non-achievement.

The third speaker, Miss Mildred B. Cole of Bradwell School, Aurora, Illinois, gave a discussion and demonstration on the "Use of Paper Folding in the Upper Grades." Miss Cole gave as her source the book, *Geometric Exercises in Paper Folding* by T. S. Row, published by the Open Court Publishing Company.

The speaker provided her audience with squares of colored shelf paper and gave directions for folding this into squares of various sizes, into triangles, and other plane figures including several other polygons. Miss Cole then demonstrated how various types of Christmas Tree ornaments might be made by simple folding. The speaker had two very attractive arrangements of varied and interesting patterns displayed on bulletin boards.

Between the second and third talks the Chairman of the Nominating Committee, Dr. Glen Ayre of Western Illinois State College, presented the following candidates for offices for the coming year:

Chairman—Mrs. Lucile B. Gates, Chicago, Ill.
Vice-Chairman—Dr. Ella Marth, St. Louis, Mo.
Secretary—Miss Glenadine Gibb, Cedar Falls, Iowa.

A unanimous ballot was cast for the candidates. The meeting was adjourned at 4:20 P.M.

ELLA MARTH, *Secretary*

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2203. *W. W. Funkenbusch, Michigan College of Mining and Tech.*

2209, 2213, 4. *C. W. Trigg, Los Angeles City College*

2212, 3, 4. *B. B. Libby, San Francisco, Calif.*

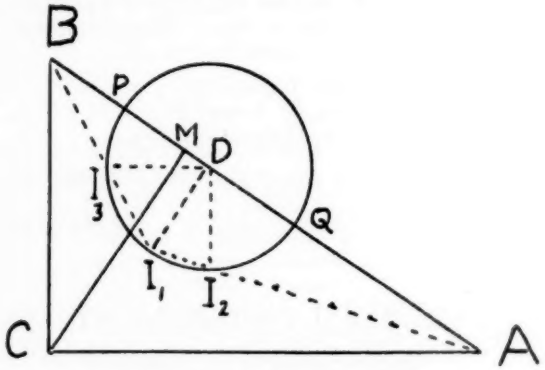
2215. *Proposed by Francis L. Miksa, Aurora, Ill.*

Given right triangle ABC, $C=90°$, drop CM perpendicular to AB, the hypotenuse. Let I_1, I_2, I_3, be the incenters of triangles ABC, ACM, BCM. Show that the area of triangle $I_1I_2I_3$ is given by

$$\triangle=\frac{a^2b^2(a+b-c)}{2c(a+b+c)^2}$$

Solution by W. J. Cherry, Berwyn, Ill.

Draw I_1D perpendicular to AB at D. With D as center and DI_1 as radius describe a circle cutting AB at P and Q. This circle passes through I_1, I_2, and I_3.



(See problem E878, *The American Mathematical Monthly*, April, 1950, p. 261)

$$\angle B=\widehat{QI}_1-\widehat{PI}_3;\ \angle A=\widehat{PI}_1-\widehat{QI}_2;\ \angle A+\angle B=\widehat{QI}_1+\widehat{PI}_1-\widehat{PI}_3-\widehat{QI}_2=\angle I_2DI_3.$$

Since $\angle A+\angle B=90°$, $\angle I_2DI_3$ is a right angle; and, with a little subtraction and substitution, it is easily shown that $\angle I_1DI_3=\angle B$ and $\angle I_1DI_2=\angle A$.

Since $\triangle I_1I_2I_3=\triangle DI_1I_2+\triangle DI_1I_3-\triangle DI_2I_3$, we have

$$\text{Area } \triangle I_1I_2I_3=\tfrac{1}{2}r^2\sin\angle I_1DI_2+\tfrac{1}{2}r_2\sin\angle I_1DI_3-\tfrac{1}{2}r_2,$$

where r is the inradius of $\triangle ABC$. Since $\angle I_1DI_2=\angle A$ and $\angle I_1DI_3=\angle B$,

$$\triangle=\tfrac{1}{2}r^2\left(\frac{a}{c}+\frac{b}{c}-1\right)=\tfrac{1}{2}r^2\left(\frac{a+b-c}{c}\right).$$

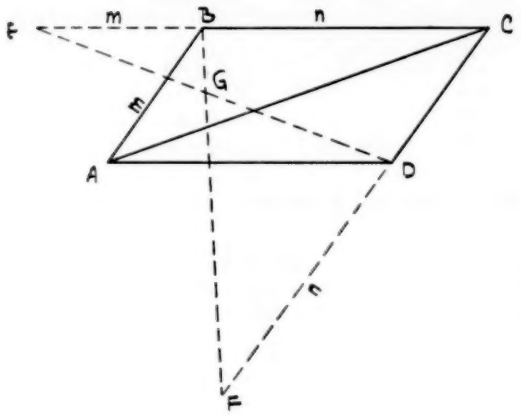
Since $r(a+b+c)=ab$,
we have

$$\triangle=\frac{a^2b^2(a+b-c)}{2c(a+b+c)^2}$$

Solutions were also offered by: Hugo Brandt, Chicago, Ill.; C. W. Trigg, Los Angeles City College; V. C. Bailey, Evansville, Ind; and Charles L. Tubbs, Racine, Wis.

2216. *Proposed by C. W. Trigg, Los Angeles, Calif.*

In parallelogram $ABCD$, let $AB=m$ and $BC=n$. CB is extended to E so that $BE=m$, and CD is extended to F so that $DF=n$. Find the necessary relation between m and n in order that the intersection of DE and BF may fall on the diagonal AC.



Solution by V. C. Bailey, Evansville, Ind.

The medians of a triangle are concurrent. AC is always a median of triangle ABD.

BF and DE will be medians of triangle ABD when $m=n$.

Therefore, m must equal n for the intersection of DE and BF to fall on the diagonal AC.

Solutions were also offered by: W. J. Cherry, Berwyn, Ill.; Sister Olivia, Milwaukee, Wis.; D. E. Palzere, York Harbor, Me.; Hugo Brandt, Chicago, Ill.; and the proposer.

2217. *Proposed by C. W. Trigg, Los Angeles, Calif.*

An integer which contains the nine non zero digits is composed of three triads. The digits of the middle triad form an arithmetic progression. Geometric progressions may be formed by taking some order of the digits of each of the other triads. Show that there is only one such integer which is a multiple of 9801.

Solution by Francis L. Miksa, 613 Spring St., Aurora, Ill.

It is easy by mere inspection of the first nine digits to see that the only two geometrical triads contained in it are 2, 4, 8, and 1, 3, 9 and this leaves 567, or 765 for the middle triad, that is in arithmetical progression. Now six permutations are possible for each of the outside triads, and with the two ways of writing the middle triad, and the two possible positions of the geometrical triads makes it possible to make 144 integers, all of which will be multiples of 9. We can now form the following table of permutations of each triad.

Triad A	*Triad B*	*Triad C*
a, b, c,	5, 6, 7 or 765	*d, e, f*
2, 4, 8	5, 6, 7 or 765	1, 3, 9
2, 8, 4		1, 9, 3
4, 2, 8		3, 1, 9
4, 8, 2		3, 9, 1
8, 4, 2		9, 1, 3
8, 2, 4		9, 3, 1

Now since $9801=9^2.11^2$ then the integer we seek will be divisible by 11. Using the well known test for divisibility by 11 we have.

$$a+c+6+d+f-b-12-e\equiv 0 \pmod{11} \quad (1)$$

$$(a+c-b-6)+(d+f-e)\equiv 0 \pmod{11} \quad (2)$$

Now we can form the following table based on (2) above.

$(a+c-b-6)$	$(d+f-e)$
0	+7
−8	−5
+4	+11
−8	−5
0	+11
+4	+7

By aid of the above table and congruence (2) we get the eight basic possible integers.

Triad A	*Triad B*	*Triad C*
248	567	319
248	567	913
842	567	913
842	567	319
428	567	139
428	567	931
824	567	139
824	567	931

The above can also be written in order (C, 567, B), (A, 765, C) and (C, 765, A) or a total of 32 possible integers, and it is now easy to test by actual division by 9801 which of the above integers will fulfill all the conditions of the problem. The integer is:

$$824 \quad 567 \quad 931 = 9801 \times 84131.$$

Solutions were also offered by: Hugo Brandt, Chicago, Ill. and the proposer.

2218. *Proposed by W. R. Talbot, Jefferson City, Mo.*

If $a+b>c$ and $a^2+b^2=c^2$, show $a^3+b^3<c^3$.

Solution by the proposer

The given conditions liken c to the hypotenuse of a right triangle. Then

$$c>a \quad \text{and} \quad ca^2>a^3$$
$$c>b \quad \text{and} \quad cb^2>b^3.$$

Adding the inequalities gives $c(a^2+b^2)>a^3+b^3$ or $c^3>a^3+b^3$.

Solutions were also offered by: Hugo Brandt, Chicago, Ill.; V. C. Bailey, Evansville, Ind.; Russell Schoene, Evansville, Ind. A. L. Leatherby, Mt. Pleasant, Iowa; W. J. Cherry, Berwyn, Ill.; and C. W. Trigg, Los Angeles City College.

2219. *Proposed by Julius Sumner Miller, New Orleans, La.*

Discover the properties of the number

$$\sqrt[3]{2+\frac{10}{9}\sqrt{3}}+\sqrt[3]{2-\frac{10}{9}\sqrt{3}}$$

One Solution—by W. J. Cherry, Berwyn, Ill.

The form of the number suggests that it is the root of a cubic equation and that it was obtained by Cardan's method for getting exact expressions in radical form for such roots. Let

$$2=-\frac{q}{2} \quad \text{and} \quad \frac{10}{9}\sqrt{3}=R$$

where

$$R=\left(\frac{p}{3}\right)^3+\left(\frac{q}{2}\right)^2.$$

From the above we get $q=-4$, $p=-2$.
Substituting these values in $x^3+px+q=0$, we get

$$x^3-2x-4=0.$$

Represent the given number by $A+B$. The other roots are

$$\omega A+w^2B \text{ and } \omega^2A+wB.$$

Second Solution by C. W. Trigg, Los Angeles City College

$$\sqrt[3]{2+\frac{10}{9}\sqrt{3}}+\sqrt[3]{2-\frac{10}{9}\sqrt{3}}$$

$$\sqrt[3]{\frac{27+27\sqrt{3}+27+3\sqrt{3}}{27}}+\sqrt[3]{\frac{27-27\sqrt{3}+27-3\sqrt{3}}{27}}$$

$$=\frac{3+\sqrt{3}}{3}+\frac{3-\sqrt{3}}{3}=2.$$

Hugo Brandt, Chicago also offered a solution.

2220. *Proposed by Julius Sumner Miller, New Orleans, La.*

Solve the equation:

$$x^4+4x^3-24x-24=0$$

Solution by W. J. Cherry, Berwyn, Ill.

Employing the resolvent cubic equation, which has the root $4\sqrt[3]{3}$, and making the proper transformation, we get

$$(x^2+2x+2\sqrt[3]{3})^2=4\left(\sqrt{1+\sqrt[3]{3}x}+\sqrt{\sqrt[3]{9}+6}\right)^2$$

$$x^2+2x+2\sqrt[3]{3}=>2(\sqrt{1+\sqrt[3]{3}x}+\sqrt{\sqrt[3]{9}+6}).$$

By the quadratic formula we get the roots

$$\sqrt{1+\sqrt[3]{3}}-1\pm\sqrt{2-2\sqrt{1+\sqrt[3]{3}}+2\sqrt{\sqrt[3]{9}+6}-\sqrt[3]{3}},$$

and

$$-\sqrt{1+\sqrt[3]{3}}-1\pm\sqrt{2+2\sqrt{1+\sqrt[3]{3}}-2\sqrt{\sqrt[3]{9}+6}-\sqrt[3]{3}}.$$

From the above we get the approximate roots:

$$2.32836, \quad -1.20283, \quad -2.56277\pm1.41485.$$

Other solutions were also offered by: C. W. Trigg, Los Angeles City College; and Margaret Joseph, Milwaukee, Wis.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

2212. *Janice A. Egeland, Clyde Lindner, Louis Roemer of Red Bank High in Eatontown, N. J.*

2213. *Clyde Lindner and Pete Koenig of Red Bank High in Eatontown, N. J., Charles Eliot, Harmon Hall School, York Harbor, Me.*

2215. *Charles L. Tubbs, Washington Park High, Racine, Wis.*

2218. *Richard Lull, Arlington Heights, Ill.*

PROBLEMS FOR SOLUTION

2233. *Proposed by W. H. Cleveland, Meridian, Miss.*

There were three men John, James and Henry and their wives Mary, Sue and Ann, but not respectively. They went to market to buy hogs. Each person bought as many hogs as that person spent dollars per hog. John bought 23 hogs more than Sue; and James bought 11 more than Mary. Each man spent \$63 more than his wife. What is the name of each man's wife?

2234. *Proposed by D. L. Foster, Florida A and M College*

If x is real, prove that $(3x^2+2)/(x^2-2x-1)$ can have all values except such as lie between 2 and $-3/2$.

2235. *Proposed by Max Beberman, Shanks Village, N. Y.*

Given a semi-circular area of radius r and a rod of length $S<2r$. Let P be a point on the rod dividing S into two lengths in the ratio $m:n$. If the rod is free to move in the semicircular area, find the area of the region in which P will always be found.

2236. *Proposed by Felix John, Ammendale, Md.*

The angle formed by a line from A of triangle ABC, to S, the circumcenter and the altitude from A, is bisected by the bisector of the angle A.

2237. *Proposed by C. W. Trigg, Los Angeles City College*

In triangle ABC, the points of contact of the incircle, center I, with a, b, c, are (A', B', C') respectively. $A'I$ meets the circle again at E. EC', AE and EB' meet BC at M, N, and P, respectively. (a) Find area of triangle MEP in terms of a, b, c. (b) Show that EN is a median of triangle MED.

2238. *Proposed by Hazel Floyd, Nashville, Tenn.*

Find the sum of n terms of the series:

$$\tan^{-1}\frac{x}{1+1\cdot 2x^2}+\tan^{-1}\frac{x}{1+2\cdot 3x^2}+\cdots+\tan\frac{x}{1+n(n+1)x^2}+\cdots$$

PATENT NEW METHOD TO PRODUCE ENZYMES ARTIFICIALLY

A new method for artificial production of enzymes, complex organic substances which speed up chemical processes such as fermentation and human digestion, is a top patent just issued.

The enzymes are produced by bacteria grown in tanks or vats on solutions of starches, proteins and bits of broken grain. This system, long sought with little success, is more efficient than producing enzymes on the surface of liquids or on solid nutrients such as yeast.

The inventors of the new process are Carl V. Smythe of Moorestown, N. J., and Billy B. Drake and Clifford E. Neubeck of Philadelphia. Their patent (2,530,210) has been assigned to the Rohm and Haas Co. of Philadelphia, a leading chemical firm.

BOOK REVIEWS

LINEAR INTEGRAL EQUATIONS, by William Vernon Lovitt, Ph.D., *Professor of Mathematics, Colorado College.* Cloth. Pages ix+253. 13.5×20.5 cm. 1950. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.50.

This is one of the reprints which Dover Publications have recently issued. Apparently, it is an exact reproduction of the 1924 edition.

Although this book was rather severely criticized in a review shortly after its publication, the fact remains that it is essentially the only elementary textbook treatment on the subject available in English. For several years, the book has been out of print and difficult to obtain, yet it has had rather extensive use.

In order to follow the treatment, the reader needs to be familar with such topic as differential equations, infinite series, determinants. There are two rather lengthy chapters on physical applications which, however, may be omitted without destroying the continuity. Those interested in a much longer review than space available here will permit, may consult the *American Mathematical Monthly*, Vol. 34, pages 142–150. (March, 1927)

CECIL B. READ
University of Wichita

STATISTICAL DECISION FUNCTIONS, by Abraham Wald, *Professor of Mathematical Statistics, Columbia University.* Cloth. Pages ix+179. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

This book should definitely be classified as a theoretical work in the field of mathematical statistics, as contrasted with a textbook in the applied field. The material is by no means elementary, and requires a considerable mathematical maturity to grasp. For example, the reader needs some knowledge of probability distributions in the infinite dimensional space, a rather thorough knowledge of calculus and of set theory.

The emphasis of the text is upon theory rather than specific methods; there are no problems or examples for the student. There is a rather extensive bibliography of over 75 items.

A rather brief note at the end of the first chapter summarizes previous ideas and results. In this it is pointed out that the book is developed from previous publications of the author, and in particular how the general theory of this book is freed from earlier restrictions, (which assumed among other things that experimentation was carried out at a single stage). This book covers the topic of multistage experimentation, and makes the design of experimentation a part of the decision problem.

Although some of the material of the book has appeared in separate papers, this is the first book length treatment. It is stated that the book was written under the sponsorship of the Office of Naval Research. It is extremely doubtful if this book belongs in a school or college library at anything of junior college level or lower; on the other hand it is almost essential in the library of any university where there is any attempt to cover the field of mathematical statistics.

CECIL B. READ

THE EVOLUTION OF SCIENTIFIC THOUGHT—From Newton to Einstein by A. d'Abro. 482 pages, 5⅜×8. 21 diagrams; 15 portraits. Second Edition 1950. Dover Publications. Price $3.95.

This book is a classic. Nearly a quarter-century has elapsed since its first edition (1927), and the improvement (if one may speak of it!) is one of extension only. The same literary excellence abounds; the same logical order. The language is amazingly free of the hypertechnical but withal accurate in all essential details. This alone is no mean task, for the recitation of ideas essentially mathematical usually demands mathematical rigor.

As the subtitle suggests, the book reviews the development of physical thought

from Newton to Einstein, and leads the reader in logical sequence from the classical order to the relativistic. The first three parts cover the standard material but with an uncommon elegance and clarity. I would recommend their reading recreationally. Indeed, the serious student of physical theory will find here a beautiful "continuum" constituting an eminently sound background for Einstein's latest achievements.

Part I—Pre-Relativity Physics
Part II—The Special Theory of Relativity
Part III—The General Theory of Relativity

The extension embraces a chapter on the 'finiteness of the universe' and a discussion of the expanding universe of Lemaitre. The hope of "field physics" and the problem of matter are looked at put as we know "the outlook is none too promising." "The problem of matter is no nearer a solution than before"; "we are faced with something we do not understand"; "the further we go the more inextricable our difficulties become"; "the existence of matter still remains a mystery."

Part IV is entitled *The Methodology of Science* and these 100 pages are nowhere excelled in temper, elegance and substance. They must be read to be appreciated, although I fear that the "traditional" philosopher will find little comfort herein! These pages are, in my opinion, so valuable to physicist *and* philosopher that they should be bound separately and made required reading. They are further evidence that physics and philosophy have no line of boundary but are indeed of *one* purpose: to bring harmony and order into the apparent hopeless chaos of experience and experimental fact.

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

CASE 3—THE EARLY DEVELOPMENT OF THE CONCEPTS OF TEMPERATURE AND HEAT. THE RISE AND DECLINE OF THE CALORIC THEORY. Prepared by Duane Roller. Harvard Case Histories in Experimental Science; James Bryant Conant, General Editor. Paper. 106 pages. Harvard University Press. 1950. Price 50 cents.

For those who are not familiar with the *Harvard Case Histories in Experimental Science* it appears appropriate to give a generalized account of their intent and ambition. It is unequivocally clear that *all citizens* should be informed on matters scientific, but the problem which has always beset us is how to do it. These case histories embrace one such attempt, being designed, as they are, primarily for students of the humanities and/or social studies.

The study of modern science by this group presents real and often insurmountable hazards. It requires substantial competence in the prerequisites, chiefly of which is mathematics, an equipment which few in this group come to possess. To put before this "humanist" or "social scientist" a modern scientific tract would be meaningless. Might it be of some help to his understanding if we pursue with him the *historical development* of some restricted facet of the scientific gamut? Any scientific achievement is the result of the accretion of exciting findings over years of history. Perhaps if we carry our student over the historical course his vision and understanding will be enhanced and his appreciation of modern scientific progress extended and made real. As Conant puts it in the Foreword: "An intimate acquaintance with a relatively few historic cases should assist him in finding his way through the complexities of modern investigation . . . " The belief foundational to this case history program is this: "that a detailed knowledge of a few epoch-making advances in science will provide a key to a better comprehension of the modern world."

This monograph then, is devoted to the historical development of the concepts of temperature and heat. The sections carry the following titles which are self-explanatory:

1. Evolution of the Thermometer
2. Joseph Black's Discoveries of Specific and Latent Heats
3. Count Rumford's Investigation of the Weight Ascribed to Heat
4. Count Rumford's Experiments on the Source of the Heat that is Excited by Friction
5. Humphry Davy's Early Work on the Production of Heat by Friction

The thread of scientific history from crude thermometry and speculations on the nature of heat to the modern concept of heat as a form of motion is very readably woven. The exposition in these 100 pages is elegantly put up and they are delightful to read. *Whether the intention of the monograph is successfully met I personally doubt.* It seems to me that a proper understanding, let alone an appreciation, of the science involved here demands more than the student for whom it is designed can bring to it. I got a great deal out of, but I brought some background to it. I feel about it very much as I feel about "survey courses" in the sciences—they ought to be given to seniors and graduate students who have had some substantial training in the sciences themselves and who are thus prepared to put the warp and the woof into a *whole* cloth! This cannot be done *for* freshmen and freshmen cannot do it! Furthermore, science majors rarely bring the loose ends together, for this is hardly ever done in the courses themselves. The professors are too busy pouring out the *isolated* facts! I would, however, recommend these monographs very seriously to teachers of physics so that they can give more history (and history that is more accurate!) in their courses, a point of view I have presented elsewhere (*American Journal of Physics*, Feb. 1950).

I look forward eagerly to learning the decision of the Harvard people after this program has been "tested." And here again is a dilemma raised: How will its efficacy be tested? The fruits of this endeavor, it seems to me, can hardly be realized in less than a generation. By then we have moved again into alien territory and the citizen finds himself afresh in a sea of complex technical knowledge. If, during the past 40 years, we had taught the reading, writing, and 'rithmetic of old, and if we had emphasized the *thinking* process, our citizenry might more capably read what is going on in the world.

But the effort is a noble one and the Harvard program attests to the freedom we still have to explore educational horizons. Some of us have feared that this too was lost!

JULIUS SUMNER MILLER

MAN THE MAKER—A HISTORY OF TECHNOLOGY AND ENGINEERING, by Robert J. Forbes, *Professor of the History of Science and Technology at the Amsterdam Municipal University, Netherlands.* 329 pages. Bibliography. Index. Henry Schuman, New York. 1950. Price $4.00.

This book is very appropriately titled. It is a short account of man's conquest of materials—*Homo faber, Man the Maker*—and it recites some highlights in the progress (?) of man as a tool-using animal. From the beginning man's principal concern has been to "control" Nature, that is, to provide devices and materials in order, first, to survive, and second, to improve his lot. (Whether this thesis holds for modern man is now moot, for there is great doubt whether his lot *is* improved or whether indeed he can survive the fruits of his intellect!)

A recitation of man's discoveries and inventions removed from the cultural, social, economic, philosophic, and spiritual factors would be a barren exposition. On this count if on no other *Man the Maker* is admirably put up. The author weaves the technical achievements into the broader aspects of man's culture and thus they are seen in the larger and better perspective. The "progress" therefore, takes on a sounder complexion when it is seen against the background of an *accumulated heritage.* The separate events, like the wheel, the steam engine, the building of roads, are shown to be the results of the strivings of all men over long generations, and thus they demonstrate the essential singleness of purpose

of all peoples, despite the transient impediments (like war and geographical limitations) which temporarily obstruct cultural progress.

The author gives some discussion on the more significant eras in man's technological and engineering achievements . . . antiquity, the ancient East, the Greeks and Romans, the Medieval era, the age of steam, of electricity, of steel, of rubber, of oil. The exposition is smooth; the thread fairly unbroken. Any attempt at either intensive or extensive treatment would obviously involve colossal volumes and would undoubtedly serve the purpose of the specialist only. This volume is good for the specialist and the general reader alike.

Considering the formidableness of the subject Professor Forbes has made a valuable contribution to general reading in science. The bibliography is especially useful to those who may wish to extend their reading. The Epilogue is provocative: "No world can be built on the basis of material progress alone."

JULIUS SUMNER MILLER

CROSS-COUNTRY, GEOGRAPHY FOR CHILDREN, by Paul R. Hanna and Clyde F. Kohn. Cloth. 28 Maps, 142 illustrations. 160 pages. 27.5×21.5 cm. May 1950. Scott, Foresman and Company, Chicago. $2.20 list price.

This book is the Fourth Grade text in the Social Studies Series: Curriculum Foundation Program. It presents geography through the travel experiences of two children, motoring east to Washington, D. C. from their home in Los Angeles. Its story will appeal to the Fourth Grade child. It is more than a story, however. Its geography is real and an interesting and functioning part of the travel experiences. It is on the observational level and within the grasp of the nine year old.

VILLA B. SMITH
John Hay High School
Cleveland, Ohio

FUNDAMENTALS OF ORGANIC CHEMISTRY, by James Bryant Conant, *President of Harvard University and formerly Sheldon Emery Professor of Organic Chemistry*, and Albert Harold Blatt, *Professor of Chemistry, Queens College*. Cloth. Pages ix+413. 14.5×22 cm. 1950. The Macmillan Company, New York, N. Y. Price $4.00.

Originally planned as a simplified and abbreviated version of the third edition of the familiar *Chemistry of Organic Compounds*, this text has actually emerged as a completely new book excellently designed as a brief course for students concerned with biology, medicine, agriculture, and industry. The authors have exercised commendable restraint in not attempting to write an all-inclusive textbook, as well as expert judgment in their choice of material. The fundamentals of organic chemistry are covered in a simple, lucid manner. In addition interesting discussions of certain important biological and industrial applications of organic chemistry are included. The text is carefully organized and well written. All in all, the authors have deftly handled the very difficult problem of presenting an adequate and balanced treatment of organic chemistry which can be covered in a one semester course.

Beginning unconventionally, with the "conventional Conant" first chapter on the alcohols, the book retains the traditional separation of aliphatic and aromatic chemistry. The alkanes are discussed in Chapter III, after the alkyl halides and ethers; chapter V, following that on unsaturated hydrocarbons, is devoted to a treatment of gasoline and rubber. An excellent chapter on biochemical processes precedes the introduction of aromatic compounds. A total of eighty pages is devoted specifically to the chemistry of aromatic compounds. The last three chapters deal with alicyclic compounds, heterocyclic compounds, and natural and synthetic drugs, respectively. A well selected list of questions and problems follows each chapter.

No attempt is made, in this brief book, to interpret the mechanisms of reac-

tions from an electronic standpoint. In general, the presentation is wisely aimed at students few of whom will be specialists in chemistry, but all of whom are future citizens. The chemistry is sound; the statements that Markownikoff's rule "*applies only to hydrocarbons*" and that "it is still unsettled whether in the bisulfite addition compound the sulfite group is linked to carbon through oxygen or sulfur" are somewhat misleading, but these are relatively minor points.

"Fundamentals of Organic Chemistry" can be recommended without reservation as the basis for a pedagogically sound, well balanced, and modern course for the non major and particularly for those students who plan to enter medicine or some phase of biology.

CALVIN A. VANDERWERF
University of Kansas

GENERAL CHEMISTRY, by John A. Timm, *Professor of Chemistry and Director of the School of Science, Simmons College.* Cloth. Pages xii+764. 15×23 cm. 1950. McGraw-Hill Book Company, Inc., New York, N. Y. Price $4.50.

It has always seemed to the reviewer that Professor Timm has a rare knack for writing just as he teaches, and he is obviously an excellent teacher. His second edition of *General Chemistry* retains the easy, conversational style of the first. One gains the impression that the author is taking the student into his confidence in a joint enterprise, and this fact must do much to allay the fears and suspicions of the beginning student who may be afraid that chemistry will prove extremely difficult. In fact the book appears to be pitched at the level of the average, rather than the superior, student, but any student who masters the material it presents will possess an excellent foundation for future courses in chemistry.

The presentation of theories and principles has not been changed greatly from that in the first edition; in general, theories are introduced after the descriptive material upon which they are based has been presented. The descriptive chemistry of the elements and their compounds has received greater emphasis in this edition. The material on nucleonics has been brought up to date in an interesting chapter on "Transmutation and Nuclear Energy." New material on the silicones, the structure of silicates, the structure of sulfur, the electronegativity scale, and resonance has been added. In general the material, both descriptive and theoretical, on organic compounds has not been brought up to date to the same extent as has the remainder of the text. Some teachers may feel that treatment of the writing and meaning of ionic equation is not adequate. Numerous helpful diagrams and recent photographs have been added throughout the book. A reasonable number of well chosen exercises and reading references are provided at the end of each chapter. The book is substantially and attractively bound and clearly printed on excellent paper.

In general, the author's treatment is consistent and logical; the student's questions are answered as they naturally arise. This fine text is one which may be used with pleasure, by the student as well as the teacher, and certainly should be considered for the general college course.

CALVIN A. VANDERWERF
University of Kansas

PHENOMENA, ATOMS AND MOLECULES, by Irving Langmuir. Cloth. Pages xi+436. 14.5×23.0 cm. 44 Figures and 45 Tables. 1950. Philosophical Library. New York.

This volume might be considered a sort of Langmuir Anthology. It has little that is new save the Introduction and a bibliography of some 200 or more titles. Its eighteen chapters are assembled from papers that have been published over a spread of thirty years in a number of different scientific magazines. The oldest paper bears the date of 1914 and the most recent, 1945.

The basis of selection seems to be in terms of readability by and of interest

to the non-technical reader or the scientist of another specialty than that of the author.

Its offerings include; Atomic Hydrogen (which has about one third of the pagination), Surface Phenomena, Molecular and Atomic Structure and Valence. The three first chapters are addressed to: Science and Common Sense; World Control of Atomic Energy and Science Legislation. The paper on Surface Chemistry, given at the time the author received the Nobel Prize, is the book's fourth chapter. Particularly helpful is the Introduction which serves to integrate, partially by biographic comments, the somewhat dispersive impressions created by the unannotated table of contents.

The volume, by virtue of its light-weight paper, is compact and surprisingly convenient to handle considering the number of pages. Its principal disappointment is its "inflationary" price of $10.00. Even so, Dr. Langmuir's admirers, of which there are many, will be grateful to him for thus assembling some of his most noteworthy writings under one cover.

B. CLIFFORD HENDRICKS
University of Nebraska

TEXTBOOK OF INORGANIC CHEMISTRY, by J. R. Partington, *Professor of Inorganic Chemistry, University of London, Queen Mary College.* Cloth. Pages x+996. 14×21.5 cm. Sixth Edition, 1950. Macmillan and Co., Limited, London. Price $3.75.

Because of its wealth of descriptive material, this text has for many years been extremely valuable to the inorganic chemist, who has, in this country, used it primarily for a reference book. The present revision, the first since 1937, is, therefore, of considerable interest.

The very elementary portions of the previous editions have been largely eliminated or condensed without destroying the value of the book as a reference or textbook. The sections on atomic structure and the electronic theory of valence have been extended, and material dealing with directed covalent bonds and resonance has been added. Much additional information is found on the rarer elements, particularly the metals.

The treatment of strong electrolytes has been brought up to date. In addition, sections on pH, hydrolysis, titration and indicators, and buffer solutions have been added.

Inorganic chemists, particularly those interested in the descriptive aspects of the subject, will find several important topics omitted. The complex hydrides of the Group III elements are not discussed. No mention is made of the newer methods for the preparation of the simple Groups III and IV hydrides. The section dealing with acid-base theory is extremely brief, there being no mention of the Brönsted-Lowry, the solvent system and the Lewis electronic concepts. There is no description of the ion-exchange method for the separation of the rare earths.

On the whole, however, the book is well worth its relatively modest price. This reviewer has found it to be an excellent revision of an important inorganic book.

JACOB KLEINBERG
University of Kansas

PLANE AND SPHERICAL TRIGONOMETRY, Revised Edition, by John A. Northcott, *Professor of Mathematics, Columbia University.* Cloth. Pages ix+234+94. 14×21.5 cm. 1950. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $3.50.

A text book in trigonometry should not be like a popular song where, no matter how good it is, it is passé in 15 months (or 15 years). If it is true that you never know a person until you have lived with him, it may be equally true that you never know a book until you have taught it. A revised text has the advantage

that it has been taught. Its faults have been recognized and corrected, its omissions supplemented and its good parts retained.

Those who liked the 1934 edition of ***Northcott's Trigonometry*** will be pleased to find the same adherence to pure mathematics. There is no compromising nor running away from formal terminology and vigorous presentation. Definitions of trigonometric functions are given in terms of ordinate, abscissa, distance, not "vertical co-ordinate," "horizontal co-ordinate" or, worse still, left to the mercy of MP over OP in a diagram. The good student will enjoy not being talked down to and even respond to the compliment that he is considered capable of comprehending "The analytic conditions of equilibrium of coplanar forces acting on a particle."

Stress is laid upon the relationships between functions and values of functions of 30, 45, 60 degrees and their multiples. These values are further familiarized through graphing inverse trigonometric functions by plotting points rather than by reflection of the function in the line $x=y$. Identities, trigonometric equations, radian measure, the use of polar co-ordinates with graphs of equations in that system are emphasized. Skills and theory needed in the study of analytic geometry and calculus are well developed through many drawings and exercises. Computation with logarithms and drill in the use of tables is provided in the solution of both plane and spherical triangles. This work is adequate but is not given overprominence. The student of this text will know that trigonometry is something besides a tool for finding the distance across a pond, however useful that information might be. He will feel that he has encountered an amazing system of thought which turns out to be useful in unexpected places, and he will feel that there is still much to learn.

ALICE N. TUCKER
Morton High School & Junior College
Cicero, Illinois

THE FOUNDATIONS OF ARITHMETIC—A LOGICO-MATHEMATICAL ENQUIRY INTO THE CONCEPT OF NUMBER, by Dr. G. Frege, *Professor at the University of Jena*. English Translation by J. L. Austin, M.A., Fellow of Magdalen College, Oxford. Cloth. Pages xii+xi+119. 14.5×21.5 cm. 1884, English translation 1950. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

This book originally copyrighted sixty-six years ago, and the translation very recently, is a volume more profound than its title might suggest. Actually there are twice as many pages as shown above, for each page contains the original in German and on the opposite page the English translation. Some selected topics are: *Are numerical formulae provable? Are the laws of arithmetic inductive truths? Is number the property of external things? Is number something subjective? Does the number word "one" express a property of objects? Are units identical with one another? Every individual number is a self-subsistent object. To obtain the concept of Number, we must fix the sense of a numerical identity.* A sample of Frege's conclusions follows.

> I hope I may claim in the present work to have made it probable that the laws of arithmetic are analytic judgements and consequently a priori. Arithmetic thus becomes simply a development of logic, and every proposition of arithmetic a law of logic, albeit a derivative one. To apply arithmetic in the physical sciences is to bring logic to bear on observed facts; calculation becomes deduction. The laws of number will not, as Baumann thinks, need to stand up to practical tests if they are to be applicable to the external world; for in the external world, in the whole of space and all that therein is, there are no concepts, no properties of concepts, no numbers. The laws of number, therefore, are not really applicable to external things; they are not laws of nature. What they do apply to are judgements about things in the external world; they are laws of the laws of nature. They assert not connexions between

phenomena, but connexions between judgements; and among judgements are included the laws of nature.

Teachers who have had some graduate courses in mathematics should find this book interesting. Others who like and understand the principles of philosophy and logic can spend a profitable session, or more, with this book written by Gottlob Frege whose writings have anticipated many of the discoveries of Bertrand Russell.

JOSEPH J. URBANCEK
Chicago Teachers College

BASIC MATHEMATICAL ANALYSIS, by H. Glenn Ayre, Ph.D., *Professor of Mathematics and Director of General College Division, Western Illinois State College, Macomb. Ill.* Cloth. Pages xvi+584. 15×23 cm., 1950, McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, 18, N. Y. Price $5.00.

"This text was awarded first prize in the McGraw-Hill Awards for textbooks in Junior College Technical Terminal Education." This clearly written and well printed mathematics text, deserves the award it received.

The title *Basic Mathematical Analysis* describes the content and organization of the book. It is one of a number of texts in which the sorting of mathematical knowledge into tight compartments labeled, Algebra, Geometry, etc., has been discarded and the result is a logical development of mathematics. The author's plan of organization is simple and logical—The Number System—Operations on Mathematical Quantities—Functions. Each of these divisions is carefully developed and includes the material for a terminal course as well as adequately preparing the student for more advanced work.

While the over-all plan is excellent there are portions of it's development which are open to criticism. A less formal treatment of rate of change would seem desirable and then only if its use is carried throughout the book, in, tangents to curves, expansion in series, graphing, etc. Some of the minor criticisms include the inconsistency of proving a definition (p. 32), proving the theorem on Synthetic Substitution by example only (p. 296) when the remainder theorem is proved. On p. 264 division by zero is present in the treatment of perpendicular lines (elsewhere the exclusion of division by zero has been carefully handled). The elimination of the xy term is not handled well for the central conic (Ex. 2, p. 406). The complicated formula for tan θ (15–35 p. 404) is excellent when it precedes the work on double angles but there seems to be no excuse for it in this book since the double angle is treated earlier.

The book has more than enough material for the usual 10 hour freshman mathematics sequence and offers ample choice of material to satisfy the needs and interests of both students and teacher. It is the hope of this reviewer that this text will attract enough attention so that more students and teachers may experience the exhilaration that this approach to mathematics can give.

CHARLES W. MORAN
Wright Junior College
Chicago, Illinois

Self-locking staple to hold wire fencing to a wooden post, recently patented, resembles the ordinary U-shaped staple but has outward projecting barbs near the pointed ends. These bite into the wood when an attempt is made to pull the staple out of the post.

It is easy for all of us to shirk the discussions of current issues under the plea of remaining impartial; it is a temptation to remain a silent coward and think oneself a tolerant spectator.—JANE ADDAMS.